DESIGN OF PRESTRESSED CONCRETE BRIDGE USING PCI-GIRDER BY IMPLEMENTING THE CONCEPT OF BUILDING INFORMATION MODELING (BIM)

UNDERGRADUATE THESIS

Written by:

AFDHIL
NIM: 2110922064

DEPARTMENT OF CIVIL ENGINEERING
FACULTY OF ENGINEERING
ANDALAS UNIVERSITY
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Submitted as a requirement for completing the Undergraduate Program in the Department of Civil Engineering, Faculty of Engineering, Andalas University

Written by:

AFDHIL
NIM: 2110922064

Supervisor:
Ir. MASRILAYANTI, S.T.,M.Sc.,Ph.D

DEPARTMENT OF CIVIL ENGINEERING
FACULTY OF ENGINEERING
ANDALAS UNIVERSITY
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APPROVAL SHEET OF UNDERGRADUATE THESIS

DEPARTMENT OF CIVIL ENGINEERING – FACULTY OF ENGINEERING

UNIVERSITAS ANDALAS

DESIGN OF PRESTRESSED CONCRETE BRIDGE USING PCI-GIRDER BY IMPLEMENTING THE CONCEPT OF BUILDING INFORMATION MODELING (BIM)

Written by :

Name : AFDHIL

NIM : 2110922064

Supervisor:

Ir. Masrilayanti, S.T.,M.Sc.,Ph.D
NIP. 197512192001122001

Knowns by,
Head of Civil Engineering Department,

Ir. Sabril Haris HG, S.T., M.T., Ph.D.
NIP. 197610012000121003

THESIS DEFENSE FORM

DEPARTMENT OF CIVIL ENGINEERING – FACULTY OF ENGINEERING

UNIVERSITAS ANDALAS

Today, **Tuesday, January 21, 2025**, the Thesis Defense for student has been held:

Name	:	**AFDHIL**
NIM	:	**2110922064**
Title	:	**DESIGN OF PRESTRESSED CONCRETE BRIDGE USING PCI-GIRDER BY IMPLEMENTING THE CONCEPT OF BUILDING INFORMATION MODELING (BIM)**

Examiners Team:

Head of Examiner	:	**Yosritzal, S.T., M.T., Ph.D.**
Member of Examiner	:	**Ir. Masrilayanti, S.T.,M.Sc.,Ph.D**
		Ir. Jati Sunaryati, S.T, M.T, Ph.D.

DECLARATION OF AUTHENTICITY

The undersigned, I:

Nama	:	**Afdhil**
Place, Date of Birth	:	**Bengkulu, 05-09-2003**
NIM	:	**2110922064**
Address	:	**Jl. H A Rahman No.43 Betungan, Selebar, Bengkulu City, Bengkulu**

Stating truthfully that the THESIS entitled:

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What I wrote was really my own work and was not plagiarism or a plagiarization of someone else's thesis.

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Thus, I make this statement in truth, to be able to be used as it should.

Padang, 23-01-2025

Afdhil
NIM:2110922064

ABSTRACT

This research focuses on designing prestressed concrete bridges using PCI-Girder (Precast Concrete I-girder) by implementing the Building Information Modeling (BIM) concept to improve the calculation, planning, and design processes. The main purpose of this research is to develop a comprehensive design of prestressed concrete bridges that can withstand various loads, such as dead loads, live loads, and environmental factors, by using PCI girders for efficient structural performance. The study also investigates the application of BIM to aid in structural modeling, load calculation, and structural detailing, which ensures accuracy and optimizes the design process. Through the application of BIM, this research shows how integrating digital modeling and data management can streamline design workflows and improve the accuracy of structural analysis. In addition, the research evaluates the advantages and challenges associated with using BIM in the context of prestressed concrete bridge design, as well as identifies potential improvements in design accuracy, error reduction, and interdisciplinary communication. A detailed engineering design (DED) for the prestressed concrete bridge was developed, covering all the important structural elements and specifications, guided by the results of BIM-based 3D modeling. This study highlights the potential of BIM in modern infrastructure projects, especially in the design and construction of prestressed concrete bridges, and provides recommendations for its future application in similar projects. In this design process, Midas Civil 2022 and Autodesk Revit 2023 software are used to optimize the analysis as well as design and model the bridge structure. Midas Civil 2022 is a structural design and analysis software used for the calculation of bridge loads, deformations, and structural stability. This software allows for more in-depth and accurate analysis, which is crucial in the design of prestressed concrete bridges. Meanwhile, Revit is used to build 3D modeling of bridges, enabling clearer visualization and better coordination between disciplines, as well as supporting BIM in accelerating the planning and design process.

Keywords: Prestressed Concrete Bridge, Building Information Modeling (BIM), Structural Design, Detailed Engineering Design (DED), Midas Civil 2022, Autodesk Revit 2023.

PREFACE

All the praise and deep gratitude to our almighty, Allah SWT, for the mercy and grace given to the author that made this undergraduate thesis can be completed properly. Greetings and shalawat may always be devoted to the Prophet Muhammad SAW.

This undergraduate thesis entitled "**Design of Prestressed Concrete Bridge Using PCI-Girder by Implementing The Concept of Building Information Modeling (BIM)"** is made as a requirement for completing the Undergraduate Program (Curriculum Stratum-1) in the Department of Civil Engineering, Faculty of Engineering, Andalas University.

The writer would like to say thank you for all the help that has been given while doing this undergraduate thesis, either directly or indirectly during the preparation of this undergraduate thesis to complete. On this opportunity and occasion, the author would like to express his profound gratitude, to :

1. Mrs. Masrilayanti, S.T.,M.Sc.,Ph.D, The Supervisors, who have given is time, guidance, knowledge, direction, and motivation to complete this undergraduate thesis;
2. Mr. Ade Edwarlis and Mrs. Yuniarti, The author's parent, Always provide support and prayers to the Author;
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7. All friends of Civil Engineering Class 21 who always give encouragement, support, and attention to the author;
8. All people who have helped in completing this undergraduate thesis that cannot be mentioned one by one by the author

The author realizes that writing this undergraduate thesis is still far from perfect. Therefore, the author expects constructive criticism and suggestions from all parties as input for the author in the future. Hopefully, this final project will be useful and provide readers with insight, especially for the author as well.

Padang, January 2025

Afdhil

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CHAPTER I
INTRODUCTION

1.1. BACKGROUND OF THE RESEARCH

Bridges are one of the important elements in transportation infrastructure that have a strategic role in supporting the smooth mobility of goods and people and improving connectivity between regions. In Indonesia, with the increasing need for infrastructure that can support economic growth, the construction of bridges with longer spans and larger load capacity is becoming increasingly important. One of the solutions widely applied for bridges with medium to long spans is the use of prestressed concrete, which is known to have higher strength and durability than reinforcement concrete. One of the important elements in this system is the PCI (Prestressed Concrete I-Girder) beam. Characterized by high strength, material efficiency, and the ability to cover long spans, PCI beams are frequently used in modern bridge design. (Naaman, 2004).

The design of prestressed concrete bridges using PCI girders offers a variety of significant advantages, both from a technical and economic perspective. One of the main advantages is the ability of the structure to withstand larger loads with smaller dimensions. The process of prestressing the concrete makes the structure more resistant to tensile forces and able to withstand heavier loads, which is very important in the design of bridges that are in areas with high traffic volumes or less-than-ideal geotechnical conditions. In addition, the use of PCI girders as factory-manufactured precast elements allows for better quality control and reduces the risk of errors during construction, speeds up project execution time, and reduces construction costs.

However, despite having many advantages, the planning of prestressed concrete bridges with PCI girders also faces some technical challenges that need to be considered. The proper planning process requires a deep understanding of the behavior of prestressed concrete structures, load distribution, and other factors such as varying soil conditions and traffic loads. In addition, the process of transporting and installing PCI girders requires special attention so that structural elements are not damaged during delivery and installation at the construction site. Therefore, proper design and analysis are essential to ensure that the bridge structure can function optimally and safely in the long term. T.Y. Lin, a pioneer in prestressed concrete engineering, also underlined the importance of innovative approaches in bridge design to ensure structural efficiency and long-term sustainability.

Along with the development of technology in the field of construction, the concept of Building Information Modeling (BIM) has begun to be applied in the planning and construction of bridges. BIM allows designers, engineers, and contractors to collaborate more effectively in a single digital platform that contains all project-related information, from design, and structural calculations, to construction management. In the context of planning prestressed concrete bridges using PCI girders, BIM allows for more efficient integration between structural calculations, material selection, and scheduling and budget coordination. By using BIM, design changes can be implemented more quickly and coordinated, reducing the risk of errors and improving planning accuracy. According to Eastman et al. (2011), BIM enables the integration of all aspects of design and construction, including in prestressed concrete bridge projects.

As part of efforts to improve the quality of infrastructure in Indonesia, this research aims to explore and analyze the planning of prestressed concrete bridges using PCI girders, especially for medium to long bridge spans. This research will examine various aspects of planning, such as the calculation of load capacity, the selection of optimal girder dimensions, as well as the analysis of stress distribution and safety factors. In addition, this research will also integrate the concept of BIM in the planning process to improve efficiency and accuracy. The application of the BIM concept in bridge planning is expected to be a step forward in realizing more modern, efficient, and sustainable infrastructure development.

1.2. OBJECTIVE AND BENEFITS OF THE RESEARCH

The objectives to be achieved from this research can be described as follows:

1. Planning and designing a prestressed concrete bridge capable of withstanding the loads that may work;
2. Implementing the concept of Building Information Modeling (BIM) to assist calculations and modeling in the planning and design of prestressed concrete bridges;
3. Producing Detailed Engineering Design (DED) from the Planning and design of the Prestressed Concrete Bridge; and
4. Identify and analyze the advantages and disadvantages that can be taken from the application of the Building Information Modeling (BIM) concept in the planning and design of prestressed concrete bridges.

The benefits obtained from this research can be described as follows:

1. This research provides in-depth insight into the use of prestressed concrete in increasing the strength and stability of bridges.
2. Through this Undergraduate thesis, it is hoped that new guidelines and standards can be created in the design of prestressed concrete bridges, which can be used by professionals in the field of civil engineering.
3. By using the Building Information Modeling (BIM) Concept, it is hoped that it can reduce calculation errors from the design of prestressed concrete bridges
4. This Undergraduate Thesis will make a significant contribution to academic and practical knowledge about bridge planning and the application of Building Information Modeling (BIM) in the construction industry, The results of the research can be an important reference for academics, practitioners, and students who are interested in the development of modern construction technology.

1.3. SCOPE AND LIMITATION

Scope and limitation of this research by the following:

1. The bridge that will be designed on the Superstructure uses the main girder in the form of a PCI-Girder with a span of 40 meters;
2. The substructure of the bridge uses 2 abutments without pillars using piles foundations.
3. The BIM-based software used in this research is Midas Civil 2022 and Autodesk Revit 2023;
4. In this study, Building Information Modeling (BIM) is only used as an assistant for calculation and 3D modeling;
5. The BIM-based software used to help analyze the superstructure, substructure, and foundation of the bridge is Midas Civil 2022 with the help of data processing using Excel;
6. The soil data used in analyzing the substructure is fictitious;
7. The 3D modeling that will be made is a prestressed concrete bridge with BIM-based software used, namely Autodesk Revit 2023; and
8. The components modeled are only structural and architectural, while MEP (Mechanical, Electrical, and Plumbing) is not modeled

CHAPTER II
REVIEW OF LITERATURE

2.1. PRESTRESSED CONCRETE

2.1.1. Definition of Prestressed Concrete

According to SNI-2847-2019, the definition of concrete is a mixture of Portland cement or other hydraulic cement, fine aggregate, coarse aggregate, and water with or without additional admixture. Concrete is known in the construction world as a mixture of gravel, sand, cement, and water that is resistant to compression, but not resistant to tension. Generally, the value of the tensile strength is approximately (8-14) % of the compressive strength. While steel is a material that is very resistant to tension. By combining concrete and steel where the concrete withstands Compression while the tension is held by the steel will become a material that is resistant to tension and compression known as reinforced concrete. Reinforced concrete is a combination of concrete and steel passively while the combination of high-quality concrete with high-grade steel actively is called prestressed concrete. This active way can be achieved by pulling the steel by holding it to the concrete so it is stressed.

According to ACI (American Concrete Institute), prestressed concrete is structural concrete in which internal stresses have been introduced to reduce potential tensile stresses in concrete caused by loads. Prestressed concrete can be defined as reinforced concrete where internal stress is applied to reduce the potential tensile stress in the concrete resulting from the load, and for two-way slabs using at least minimum prestressed reinforcement (SNI 2847 – 2019). Prestressed concrete is reinforced concrete that has been stressed to reduce the potential tensile stress in concrete due to the application of a working load (Draft Konsensus Pedoman Beton 1998). It can be added that prestressed concrete in the broadest sense, including the state (case) in which the stresses caused by internal strains are compensated to a certain extent, such as in curved constructions (arcs). However, in this research, the discussion is limited to prestressed concrete that uses drawn steel reinforcement and is known as tendons.

2.1.2. General Principles of Prestressed Concrete

According to T.Y. Lin & H. Bruns (1981), three different concepts may be applied to explain and analyze the basic behavior of this form of prestressed concrete,

1. *First Concept - prestressed to transform brittle concrete into an elastic material.*

Eugene Freyssinet Explained that by giving precompression to the concrete material which is brittle, it will become an elastic material. Concrete that is weak in tension and strong in compression is compressed (generally by steel under high tension) so that the brittle concrete would be able to withstand tensile stress. This can be explained by the image below:

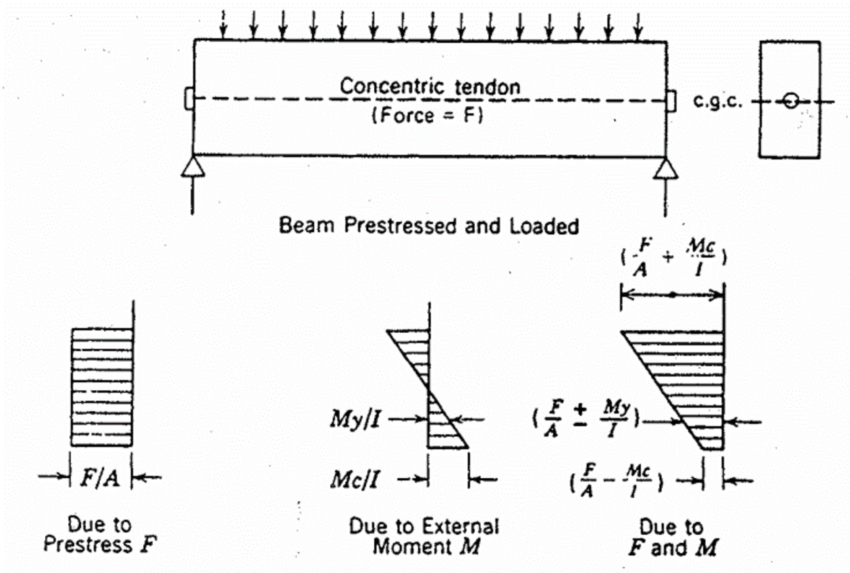

Figure 2.1 *Stress Distribution across a Concentrically Prestressed Concrete Section*

(Source: T.Y Lin & N.H. Burns, 1981)

As a result of being given a compressive force (prestressed force) F acting on the center of gravity of the concrete section, an even compressive stress will arise as follows:

$\sigma = \frac{F}{A}$ .... (1.1)

If M is the external moment at the cross-section due to the load and the self-weight of the beam, then the stress at each point along the cross-section due to M is:

$\sigma = \frac{M\,c}{I}$ .... (1.2)

where c is the distance of the neutral line to the outermost fiber of the cross-section and I is the moment of inertia of the cross-section.

If the two stresses due to the pretension force and the tension due to the bending moment are summed, then the maximum stress at the outermost fiber of the cross-section is :

- For the top fiber

$\sigma = \frac{F}{A} + \frac{M\,c}{I}$ (must not exceed the crushing tension of concrete)....................... (1.3)

- For the bottom fiber

$\sigma = \frac{F}{A} - \frac{M\,c}{I}$ (must not be less than zero).. (1.4)

So, with this internal compressive force, the concrete will be able to bear the tensile load.

2. *Second Concept - Prestressed for a combination of high-strength steel with high-quality concrete.*

High-quality concrete is the main component of all prestressed concrete elements, while high-quality steel is a commonly used material to generate prestressed forces and supply tensile forces to prestressed concrete. The combination of this system is almost the same as the concept of ordinary reinforced concrete, namely prestressed concrete is a combination of cooperation between prestressed steel and concrete, where concrete resists pressure and prestressed steel resists tensile loads. This can be explained as follows:

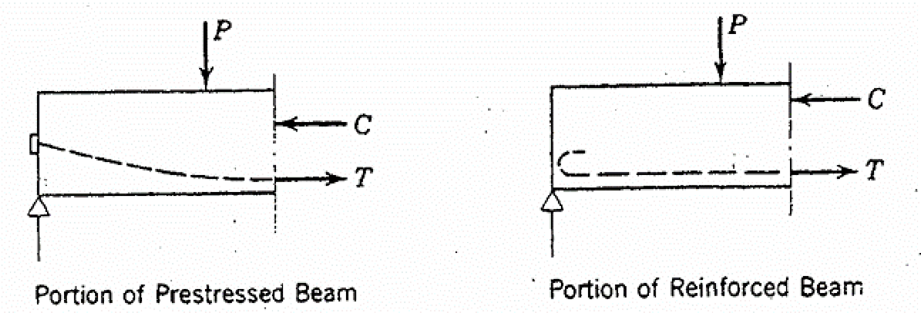

Figure 2.2 *Difference Between Prestressed Concrete and Reinforced Concrete*

(Source: T.Y Lin & N.H. Burns, 1981)

In prestressed concrete, the prestressed steel is drawn with a prestressed force T which forms a moment coupling with a compressive force on concrete C to counteract the moment due to external loads. Meanwhile, in ordinary reinforced concrete, the repeating iron resists the tensile force T due to external loads, which also forms a moment coupling with compressive force on concrete C to resist the external moment due to external loads. The combination of cooperation between high-quality steel and high-quality concrete in prestressed concrete forms a safer and more economical use than in reinforced concrete where the steel is simply planted because the two combine to create a retaining coupling against external forces.

3. *Third Concept – Prestressing to Archive Load Balancing*

This system uses pretension as an attempt to balance the forces on a beam. In the design of prestressed concrete structures, the influence of pretension is seen as the balance of Self-weight, so that rods that experience deflection such as plates, beams and girders will not experience bending stress in the loading conditions that occur. This can be explained as follows:

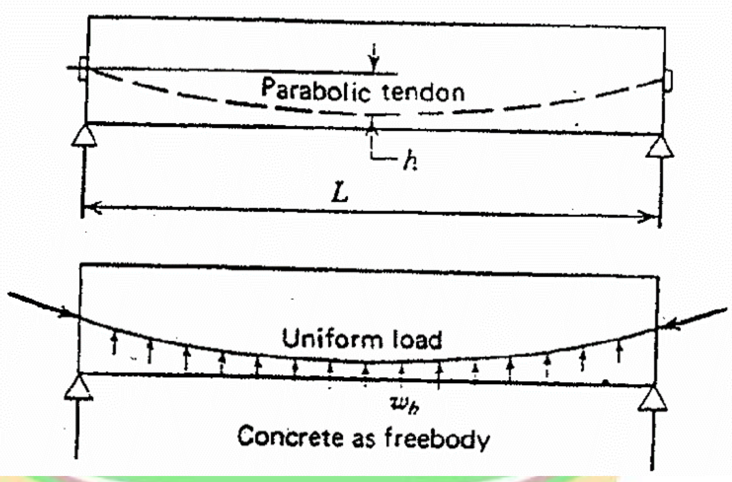

Figure 2.3 *Prestressed Beam with Parabolic Tendon*

(Source: T.Y Lin & N.H. Burns, 1981)

A concrete beam on two pedestals (simple beam) that is given a prestressed force F through a prestressed cable with a parabolic trajectory. The load due to the prestressed force that is evenly distributed upwards is stated:

$$W_b = \frac{8.F.h}{L^2}$$

Where : W_b : The load is evenly distributed upwards, due to the prestressed force F

F : Prestressing stress

h : Sag of parabola

L : Length of span

The even load due to the downward load will be offset by the evenness force due to the upward stress. The load balancing system can be applied to indeterminate static structures such as in continuous span flat plate construction. This is because the principles of balancing the load on the flat plate are carried out in two directions of tensioning so that in each direction it has an even stress distribution and does not slack due to loading.

The three systems of prestressed concrete mentioned above, are used to analyze the design principles of a prestressed concrete structure.

2.1.3. Types of Prestressed Concrete

There are 2 types of methods of applying prestressed force to concrete, i.e.

1. Pre-Tension Method

This method of , therefore it is called the pretension method. The principles of this method are as follows:

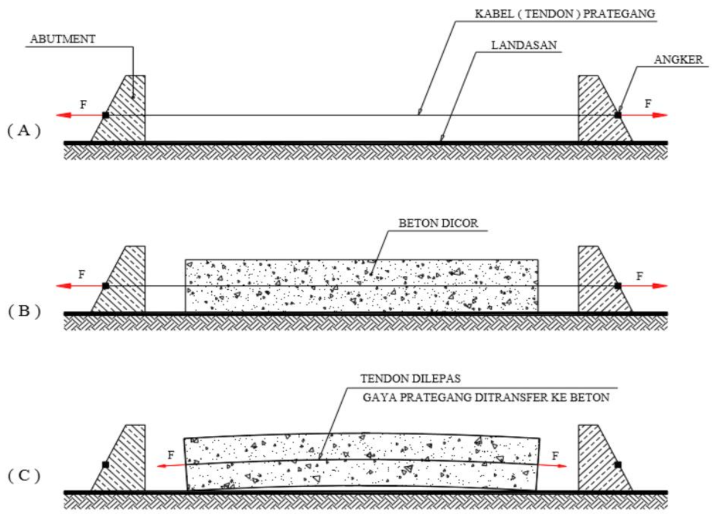

Figure 2.4 *Working Principle on Pre-Tension Method*

(Source: Kontruksi Beton Pratekan, Ir.Soetoyo)

Stage 1: The prestressed cable (Tendon) is pulled or given a prestressed force and then anchored on a fixed abutment (**Figure 2.4 A**).

Stage 2: Concrete is cast on the formwork and the base that has been prepared so that it covers the tendon that has been prestressed and allowed to dry (Figure 2.4 B).

Stage 3: After the concrete has dried and aged well enough to receive the prestressed force, the tendon is cut and removed, so that the prestressed force is transferred to the concrete (**Figure 2.4 C**).

Once the prestressed force is transferred to the concrete, the concrete block will curve upwards before receiving the workload. After the workload works, the concrete block will be flattened

2. Post-Tension Method

In the Post-Drawing method, the concrete is cast first, which has previously been prepared with a cable channel or tendon called a duct. Briefly, this method can be explained below,

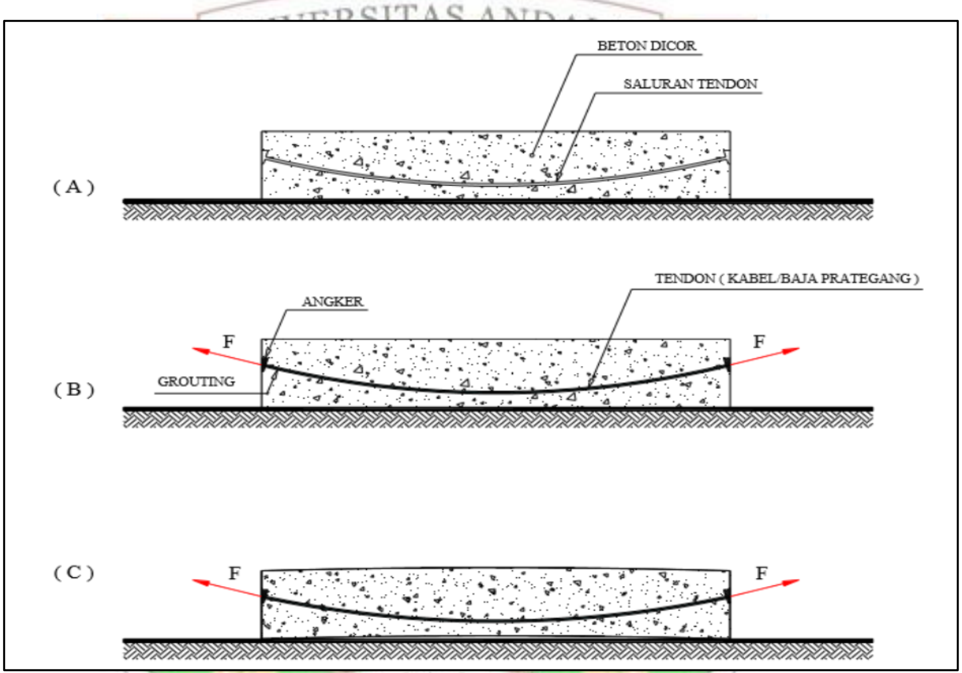

***Figure 2.5** Working Principle on Post-Tension Method*

(Sumber: Kontruksi Beton Pratekan, Ir.Soetoyo)

Stage 1: Concrete is cast with a mold (formwork) that has been provided complete with a prestressed cable channel/sleeve (tendon duct) that is installed curved according to the beam moment plane (**Figure 2.5 A**).

Stage 2: After the concrete is old enough and strong enough to bear the prestressed force, the tendon or prestressed cable is inserted in the sleeve (tendon duct), and then pulled to get the prestressed force. In this method of applying pretension force, one end of the cable is anchored, then the other end is pulled (pulled from one side). Some are pulled on both sides and anchored at the same time. After being anchored, the channel is grouted through the hole that has been provided. (**Figure 2.5 B**).

Stage 3: After being anchored, the concrete beam becomes compressed, so the prestressed force has been transferred to the concrete. Because the tendon is installed curved, the tendon tension force gives an even load to the beam in the upward direction, as a result of which the beam curves upwards (**Figure 2.5 C**).

Therefore, the construction of prestressed concrete must be designed in such a way that it has sufficient strength and the ability to serve according to needs. In addition, the construction must be durable, resistant to fire, resistant to fatigue (for repetitive and variable loads), and meet other requirements related to its use.

2.1.4. Advantages and Disadvantages of Prestressed Concrete

The advantages and disadvantages obtained in the use of prestressed concrete are explained below :

1. Advantages of Prestressed Concrete
    - The crack-free state prevents corrosion of the steel rebar.
    - Reduce the tendency of inclined cracks.
    - The structural components have a stiffer rigidity, so the structural elements can be made slimmer.
    - The use of curved tendons gives rise to vertical force components that help bear the shear.
    - The maintenance cost of prestressed concrete is smaller because there are no cracks in the working load condition (avoiding the danger of corrosion).
    - Smaller deflection.
2. Disadvantages of Prestressed Concrete
    - The use of high-quality materials results in high unit prices for work.
    - The work of prestressed concrete structures demands higher work precision and stricter supervision.
    - Additional charges are required for transportation.

2.2. CONSTRUCTION OF CONCRETE BRIDGE

2.2.1. Definition and History of Concrete Bridge

A bridge is a construction whose purpose is to continue the road through a lower obstacle which is usually in the form of another road such as a waterway or ordinary traffic (Struyk dan Veen, 1984). A bridge is a construction that functions to connect two road sections that are cut off by an obstacle with a lower surface. These obstacles can be in the form of deep valleys, river channels, lakes, irrigation canals, rivers, railways, uneven horizontal highways, and others. Bridges are the highest investment of all elements that can be found in the highway system. Any damage to the construction of the bridge can cause disturbances in the smooth rotation of the economic wheels and can cause accidents for humans. Types of bridges based on function, location, construction materials, and types of structures today have undergone rapid development by the advances of the times and technology, ranging from simple to advanced construction.

The history of the bridge dates back to ancient times with simple structures such as stone and wood, which aimed to facilitate trade and mobility. In the Middle Ages, the development of construction techniques with stone and iron bridges became landmarks in various European cities. The Renaissance and the Industrial Revolution brought significant innovations with the use of new materials such as steel and concrete, resulting in monumental bridges such as the Brooklyn Bridge and the Tower Bridge. The 20th century marked an era of modernization with the use of prestressed concrete and computerized technology in bridge design, allowing the construction of megastructures such as the Golden Gate Bridge and the Akashi Kaikyō Bridge. Today, BIM technology is central to bridge planning, enabling accurate simulations and high construction efficiency. Bridges are not only vital infrastructure but also a symbol of technological progress and global relations.

2.2.2. Characteristics and Function of Bridge Component

There are various types of components of the bridge, both structural components and architectural components, the following explains the components of the bridge along with the characteristics and functions of the bridge components:

1. Vehicle Floor Slab

   It is a part of the bridge construction that directly accepts a load of traffic running on it, which in the planning takes into account the live load/load "T" of the axle pressure of the vehicle and the construction weight it bears (including the weight of the floor itself).

2. Sidewalk

   It is a part of the bridge service used for pedestrian facilities, which is located on the left and right edges of the vehicle floor. The floor surface height of the Sidewalk is made higher than the surface height of the vehicle floor wearing course.

3. Barrier

   A bridge barrier is a safety feature installed on the edges or sides of a bridge to prevent vehicles or pedestrians from falling off or crashing into obstacles.

4. Girder Beam

   It is a part of the bridge construction that functions to carry the floor of the vehicle which then **passes** the loads to the construction part below. Typical girder beams of various shapes, especially for bridge construction, are generally I-shaped or box-shaped (inverted trapezoidal shape).

5. Bridge Pedestal

   As part of the bridge placed over the abutment and pier head as the foundation of the main girder. The materials that are often used as this base are cast iron (in the form of rolls and hinges), and super elastic rubber plates coated with steel plates (*bearing* pads).

6. Drainage

   The drainage on the bridge functions to drain the water on the floor of the vehicle to the sewer so that it does not flood the floor of the bridge vehicle, which is very disruptive to traffic.

7. Abutment

   The part that carries the two bases of the bridge located at the end of the bridge span functions to transfer the entire load of the Superstructure to the foundation/supporting soil, this part is built from reinforced concrete materials or river stone pairs equipped with wing walls.

8. Pier

   It is another part of the Substructure located on the bridge span between the base of the bridge, acting like an abutment that divides the load and shortens the bridge span. It is usually constructed of reinforced concrete or long columns (concrete or steel pipes) and on top of it is a pillar head.

9. Foundation

The foundation functions to distribute and even the load from *the Abutment* to the supporting soil. The use of the type of foundation depends on the condition of the supporting soil.

2.2.3. Classification of Concrete Bridge According to Superstructure Type

Based on the shape or type of bridge structure, bridges are distinguished from the shape of the main girder structure which supports all elements of the bridge structure and transfers all structural loads that are directly related to the substructure. The shape of the bridge structure consists of:

1. Reinforced Concrete Monolith Beam Bridge

   It is a reinforced concrete bridge that between the Main Girder and the floor slab is cast together and fused as a "T" Beam. The whole structure consists of Beams and floor slabs, which are also often installed between the beam child beams or diaphragm beams, as shown in the following picture.

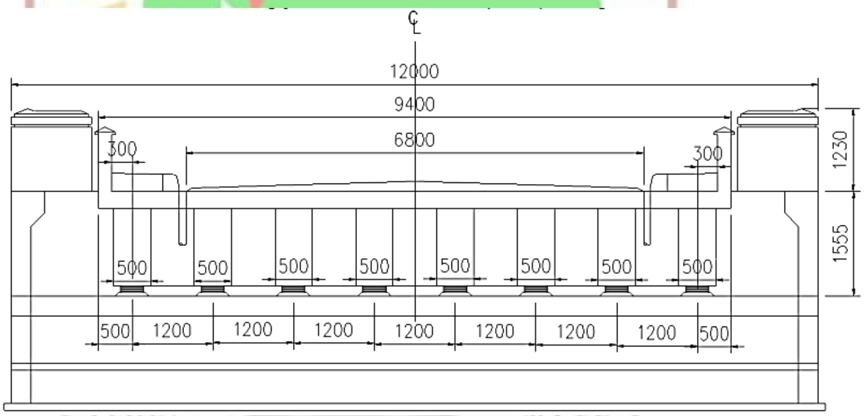

Figure 2.6 *Bridge Cross-Section*

(Source: Panduan Praktis Perencaan Teknis Jembatan)

2. Prestressed Concrete Beam Bridge

   The main girder of this bridge is a reinforced concrete beam that is pre-tensioned from the cable installed in such a way that the entire live load of the bridge can be countered by the pretension obtained from the cable pulling in the tendons placed in the beam. This bridge is often used on bridges with relatively long spans, such as mono-rail overpasses, and many others.

Figure 2.7 *Prestressed Concrete I-Girder*
(Source: PT Waskita Beton Precast TBK)

2.2.4. Structure of Concrete Bridge

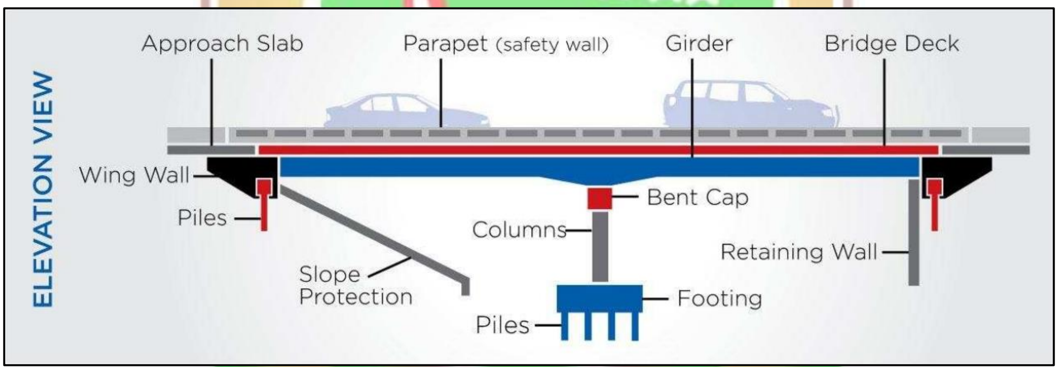

Figure 2.8 *Names of Bridge Structures*
(Sumber : Kamus Bina Marga Dep. PU.)

1. Superstructures of The Bridge

The bridge superstructure is the part that receives the direct load which includes its own weight, dead load, additional dead load, vehicle traffic load, brake force, pedestrian load, etc.

The Superstructure of a bridge generally includes:

1) Sidewalk:

a. Backings or barriers,

b. Kerb

c. Sidewalk floor slabs.

2) Vehicle floor slabs,
3) Girder
4) Diaphragm,
5) *Bearing*.

2. Substructure of The Bridge

The substructure of the bridge functions to bear all the load of the superstructure and other loads caused by soil pressure, water flow, and drift, impact, friction on the support, to then be channeled to the foundation. Furthermore, these loads are channeled by the foundation to the subsoil.

The Superstructure of a bridge generally includes:

1) Abutment,
   a. Back wall,
   b. Breast wall,
   c. Wing wall,
   d. Approach slab,
   e. Corbel,
   f. Bearing.
2) Pier,
   a. Pier Head,
   b. Pier, which is in the form of walls, columns, or portals,
   c. Corbel,
   d. Bearing.

3. Foundation

The bridge foundation functions to transfer the entire load of the bridge to the ground. Based on the system, the Abutment foundation or bridge pier can be divided into several types, including:

1) Spread footing,
2) Caisson,
3) Pile foundation,
4) Log Pile,
5) Steel Pile,
6) Reinforced Concrete Pile,
7) Precast Prestressed Concrete Pile,

a. Concrete Cast in Place,

b. Composite Pile.

2.3. BUILDING INFORMATION MODELING (BIM)

2.3.1. Definition Building Information Modeling (BIM)

Building Information Modeling (BIM) is a digital representation that contains data, objects, and facilities that can produce 3D shapes and data that can be processed by users to be extracted and analyzed against information that will be used to improve work efficiency (Associated General Contractors of America/AGC, 2005). Building Information Modeling (BIM) is a technological development in the field of AEC (Architecture, Engineering, and Construction). The resulting modeling is in the form of precise geometry and accurate data to support construction activities (Eastman, 2008). BIM or Building Information Modeling is a system or technology that includes some important information in the *Design, Construction, and Maintenance* process that is integrated into 3D modeling (Sacks et al., 2018) (Eastman et al., 2011).

According to the PUPR team and the BIM Institute in Indonesia, Building Information Modeling (BIM) is one of the developments in the construction industry that digitally presents the physical and functional characteristics of a building (Indraprastha, 2018). Therefore, each element of the building contains all the information in the development project in the form of a database (working drawings, scheduling, cost estimation, etc.) which is used as a basis for decision-making in the life cycle time curve of the building, from the initial concept to demolition. Based on the experts' opinions above, it can be concluded that Building Information Modeling (BIM) is a unit of technological devices with all processes in it working in an integrated manner on a digital model which will later be interpreted as a three-dimensional form. The system then manages and generates construction data by using 3D, real-time, and dynamic modeling software to increase the productivity of its design and construction.

2.3.2. History and Development of Building Information Modeling (BIM)

BIM was introduced in the late 1970s by Prof. Eastman at The Georgia Tech of Architecture, in an AIA (American Institute of Architects) journal entitled "Building Description System", then Robert Aish published a journal in 1986 with the title "Building Modeling: The Key to Integrated Construction CAD". In 1992, the term Building Information Modeling was first mentioned in a paper written by G.A. Van Nederveem and F. P. Tolman 1992. After a conference in 2005 that discussed the new term replacing Computer-Aided Design (CAD) technology, Jerry Laiserin, an industry analyst, argued that the most appropriate term was Building Information Modeling (BIM).

BIM or Building Information Modeling became popular in 2002 after Autodesk released a paper titled Building Information Modeling. The term Building Information Modeling resurfaced in mid-2005 when the US General Services Administration (GSA) decided to build a new courthouse in Jackson, Mississippi with a total area of 410,000 ft2 (Dinas Pekerjaan Umum, 2020). Since then, 2D (two-dimensional) software has been used to design and document all construction phases while GSA has asked its staff to switch from 2D to a 3D (three-dimensional) approach.

Meanwhile, in Indonesia, BIM is quite new in the construction industry with very limited use. Companies such as *PT. Pembangunan Perumahan* and *PT. Total Bangun Persada* is a company that has started to implement the use of BIM. After several years of BIM being implemented in Indonesia, the results are not optimal because its use is only limited to how to streamline labor needs, costs, and time. What can be done to maximize the use of BIM is to straighten out the mindset related to BIM where BIM is not only related to the use of BIM *software* but also how to manage the use of each BIM *software* so that it can achieve the desired goals.

2.3.3. Building Information Modeling (BIM) Dimension

BIM is a system, management, method, or sequence of work on a project that is applied based on related information from all aspects of the building that is managed and then projected into a 3-dimensional model (*Tim PUPR dan Institut BIM di Indonesia*, 2018). The concept of BIM envisions virtual construction before actual physical construction, to reduce uncertainty, improve safety, solve problems, and analyze potential impacts (Smith, Deke 2007). By using BIM, 3D, 4D, 5D, 6D, and even up to 7D information can be obtained, with the explanation as below.

Figure 2.9 *Building Information Modeling (BIM) Dimension*

(Source: Piranusa.com)

1. BIM 3D (Modeling*)*

   3D BIM can be said to be 3-dimensional modeling driven from the x, y, and z axes and is also referred to as coordinated modeling. The resulting 3d model can be used for schematic design, construction documentation, and visualization of objects which helps to check for errors in drawings.

2. BIM 4D (Time/Scheduling)

   In BIM 4D can reveal additional information on the model in the process of scheduling for work and is often referred to as the time element. This process usually comes in the form of detailed data plus supporting components. So that it will be able to produce better planning quality.

3. BIM 5D (*Cost Estimating)*

   BIM 5D is a cost estimation that is integrated into the scheduling of 3D object designs. With this system, you can predict the flow of costs that will likely be incurred from the modeling. You can also modify the cost at a specific time as a result of unforeseen circumstances such as design changes and other modifications.

4. BIM 6D (*Sustainability, Collision Detection, and Energy Analysis)*

6D BIM can be referred to as integrated BIM or energy analysis in buildings. This BIM involves adding other relevant information to support the management and operation of the facility in the expectation of a better result and is also able to reduce the overall energy consumption of the 3D CAD component with all aspects of management information.

5. BIM 7D (*Facility Management Application)*

   BIM 7D is used in the operation and maintenance of building facilities integrated with 7D CAD simulation to optimize asset management from the design process to demolition.

2.3.4. Benefit of Building Information Modeling (BIM)

Here are some of the benefits of using Building Information Modeling (BIM) in Construction Projects,

1. BIM has a 3-dimensional visual so that it makes it easier to understand the drawing plan to be built. The use of BIM will make it easier to calculate the volume of work quickly and accurately (Deni Deni et al., 2019).
2. BIM will provide cost information or Cost Budget Plans for each component of the work so that we can predict the estimated cost of one component of the work.
3. BIM is able to display 3-dimensional drawings on complex works such as ironing bridge structures, and other complex construction works. The use of BIM is not only to display building animation images but rather to the managerial project information quickly and accurately.
4. The use of BIM at the beginning of the work is used as a clash detection (Smith, 2007). We can find out whether this 2D plan drawing if it will be applied in the field will be a clash or not, especially between structural, architectural, and MEP (mechanical, electrical, plumbing) drawings.
5. Another benefit of using BIM is the coordination between contractors and owners or consultants easily anywhere and anytime. BIM will be uploaded to a cloud computer service that can be accessed by the owner. The owner will check the image through a cloud computer service and provide Marking if there is a mistake.

2.3.5. Building Information Modeling (BIM) Involvement in Project

One of the main goals of BIM technology is to support all processes starting from the pre-construction stage to the maintenance stage at the entire building lifecycle. The advantages of using BIM from each stage of project development are (Ramadiaprani, 2012):

1. **Pre-Construction Stage**: In the pre-construction stage, *the owner* tries to determine/estimate the size of the project according to the available project budget. Project estimates at this stage are still very rough. Using BIM, the estimated building model can be linked to a database and the project price cost will be calculated directly. In the initial stage, only model schemes are used and function to evaluate the function of the building. This can define the direction of project development right at the initial stage which can improve the overall quality of the building.
2. **Design Stage**: The design stage is a collaboration between the construction team and engineers, architects, and *owners*. At this stage, BIM must be implemented immediately. If the architect only provides 2D drawings, then the construction manager must convert the 2D drawings into 3D drawings. This coordination effort aims to reduce design errors and to better understand the work to be done.
3. **Construction and Fabrication Stages**: Aim to simulate the construction process, visualize how buildings will be built day by day with 4D models, and find potential problems faced so that repairs can be made. BIM technology allows you to identify clashes before construction takes place, which can speed up the construction process, and reduce the risk of project costs rising due to clashes and the need for solutions to correct errors. During construction, there may be design changes, thus updating the estimated cost and implementation schedule. BIM technology can facilitate the fabrication process. The 3D elements of the model can be sent to the production process element factories automatically.
4. **Maintenance Stage**: BIM models are full of information that can be useful for establishing operational processes. This can support the monitoring of the project control system.

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2.3.6. Building Information Modeling (BIM) Software

Software BIM dapat dipakai tergantung pada dimensi apa yang digunakan. Software tersebut meliputi dimensi 3D BIM (Modeling), dimensi 4D BIM (Time/Scheduling), dimensi 5D

BIM (Cost Estimating), dimensi 6D BIM (Sustainability, Collosion Detection, dan Energy Analysis), dan dimensi 7D BIM (Facility Management Application). Beberapa software BIM yang dapat digunakan berdasarkan dimensinya dapat dilihat pada Tabel 2.2 berikut.

Table 2.1 *BIM software by dimensions*

Dimensi	Fungsi	*Software*
3D	Modeling	Autodesk Revit, Graphisoft® ArchiCAD, Bentley® Architecture, Tekla® Structures, etc.
4D	Time/Scheduling	Autodesk Navisworks, Synchro, Navigator, Vico Control, etc.
5D	Cost Estimating	Autodesk® Quantity Takeoff, etc.
6D	Sustainability, Collision Detection, and Energy Analysis	Autodesk Ecotect Analysis, Autodesk Green Building Studio, Graphisoft EcoDesigner, etc.
7D	Facility Management Application	Bentley Facilities, Vintocon ArchiFM (For ArchiCAD), Onuma System, EcoDomus, etc.

In this discussion, the *software* that will be used is *Autodesk Revit* which works at the modeling stage.

2.4. MIDAS CIVIL 2022

2.4.1. Introduction of Midas Civil 2022

Midas Civil is one of the most commonly used bridge design and analysis software today that combines the power of modeling with exclusive analysis features and makes bridge modeling and design efficient for engineers. Midas Civil provides more practical features for simpler and more flexible bridges to handle complex geometries. The software includes a variety of design guidelines that are very useful for engineers looking for the ideal design. Midas Civil will ease the work of engineers and make bridge design more accessible through this software(Midas, 2022)

MIDAS Civil is a program created for structural analysis and structural design in the field of civil engineering. This software is devoted to the introduction of structural planning systems which includes analysis and how to optimize a design specifically in bridge planning. MIDAS

Civil is a solution to optimize the planning of a bridge structure and other types of structures. This software has the ability to analyze types of structures such as prestressed concrete, suspension bridges, cable bridges and other conventional bridges This program can be applied to several types of areas or projects, such as:

- Analysis and planning for all types of bridges such as bridges with reinforced concrete structures, steel, composite, prestressed, suspension, and cable bridges.
- Heat analysis of hydration from concrete such as abutments, piers, breakwater, and foundations.
- Underground structures
- Industrial and factory facilities
- Public facilities such as ports, airports, railway stations, dams and other transportation facilities

2.4.2. Advantages and Disadvantages of Midas Civil 2022

The disadvantages and shortcomings in the use of Midas Civil in conducting structural analysis are explained below,

1. Advantages of Midas Civil 2022
   - **Friendly User Interface**, The User Interface can be directly linked to the User's flexibility to model and make changes to it. The Midas Civil GUI is designed to give users complete freedom and convenience when modeling bridges.
   - **Intuitive modeling**, Midas Civil provides users with unlimited and efficient modeling methods for any project. Creating nodes and elements, such as CAD programs, as a conventional modeling approach as well as having the Bridge Wizards feature can create a complete bridge model for you in the blink of an eye, and one can make any modifications to the model, thus giving complete freedom to its engineers. Other efficient approaches, such as CAD import, table format modeling, and code format modeling are also available.
   - **Complete Analysis Options**, As one of the best structural design and analysis software, Midas Civil performs all the essential analyses required for primary bridges, such as Moving Load Analysis, Construction Stage Analysis, EigenValue analysis, and Linear and Non-Linear Analysis. But when high-level analysis is required for complex bridges such as Bend Analysis, Cable Style Tuning, Rail

Structure Interaction, and Completion Analysis, it can also be done easily on Midas Civil.

- **Provides accurate results**, load combinations based on specified design standards and can provide results that are compatible with MS Excel, which allows for easy extraction of results, and users can review all analysis and design results systematically.

2. Disadvantages of Midas Civil 2022

- **Limitations in Integration with Other Software**, Although Midas Civil provides a wide range of features for structural design and analysis, its integration with other software in BIM workflows or for specific analysis may not be as comprehensive as more integrated solutions.
- **Requires High Hardware Specifications**, To run Midas Civil smoothly, it is often necessary to have strong enough hardware specifications. This includes the need for fast processors, adequate RAM, and graphics cards capable of handling intensive graphics processing. Users who do not have adequate hardware may experience slow performance or other issues.
- **Training Cost and Availability**, The use of Midas Civil often requires a high initial investment in terms of software licensing and also the cost for appropriate training. This can be a barrier for small companies or individual users who are new to the industry.

2.4.3. User Interface of Midas Civil 2022

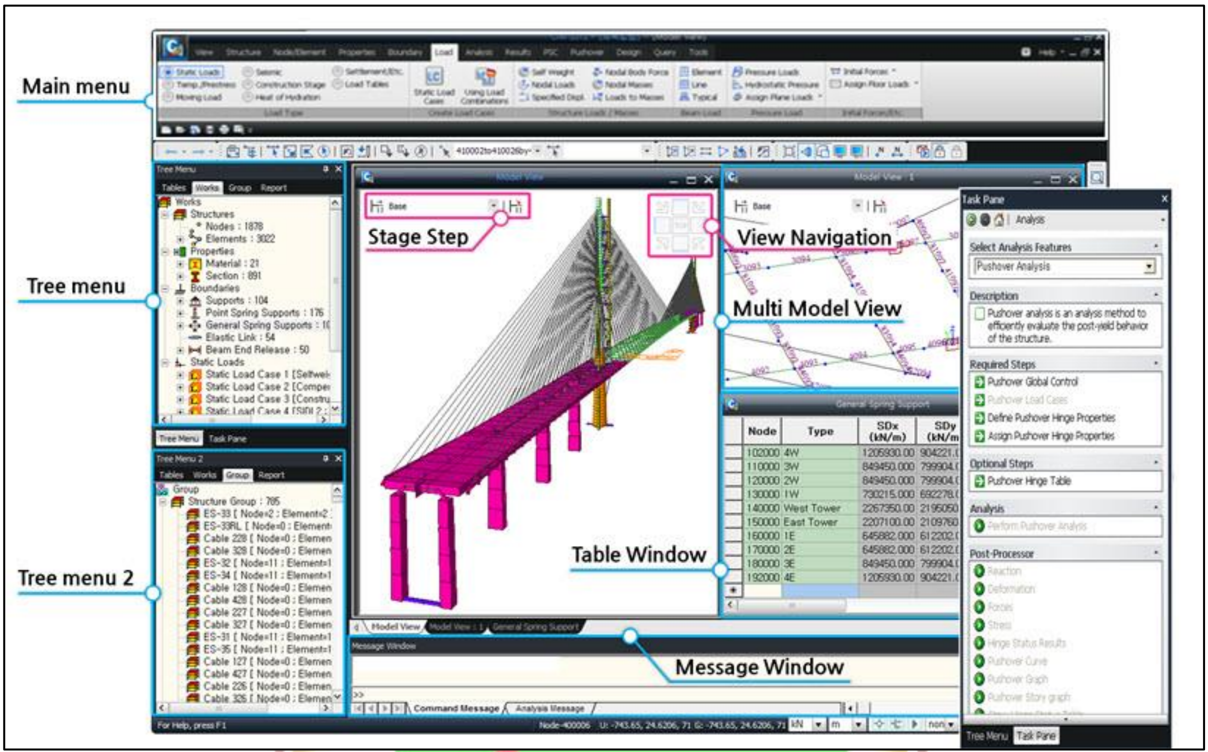

Figure 2.10 *User Interface Midas Civil 2022*

(Source: Manual.Midasuser.com)

The following is an explanation of each part of the Midas Civil 2022 Interface listed in Figure 2.6,

1. Main Menu

   The Main Menu accommodates all the commands and shortcut keys that are required for operating Midas Civil.

2. Tree Menu

   A series of work processes, from modeling to analysis, design, and generation of calculation sheets, are listed systematically. The Tree Menu guides the required procedure and invokes the relevant dialog box so that even a beginner, as well as an expert, can efficiently perform the work without an error.

3. Tree Menu 2

   Simultaneously used with the Tree menu, Work tree, and Group information can be examined more conveniently. In addition, it boosts efficiency by providing an element and boundary input dialog box with a Work tree simultaneously.

4. Stage Step

Using this drop-down menu, Construction Stage can be easily chosen for checking a structure by stages.

5. View Navigation

   Useful for displaying modeling from different perspectives

6. Toolbar

   It contains a menu icon that symbolizes each function, which allows easy access to frequently used menus. In addition, similar icon menu types are grouped by tabs (Tabbed Toolbar)

7. Task Pane

   Useful for displaying work procedures for advanced analysis functions and description of input items, allowing users to work easily.

8. Context Menu

   Simply right-click on the top of the model window to run the context menu to use the tools we use frequently depending on the work situation, the selected entity, and the click location to reduce mouse movement.

9. Table Window

   Table Window generates various data inputs and analysis results in the form of spreadsheet-formatted tables, similar to MS Excel.

10. Message Window

    Useful for displaying various information and warning or error messages that are useful for modeling and analysis.

11. Command Line

    Useful for Inserting Command Keys to execute Commands.

12. Status Bar

    It is useful to display the coordinates according to each coordinate system, and unit system, select filtering options, control the location of element snaps, etc., which will improve the working efficiency.

2.5. AUTODESK *REVIT* 2023

2.5.1. Introduction Autodesk Revit 2023

Autodesk Revit 2023 is one of the BIM-based software that can be used to design, document, schedule, operate, and maintain an infrastructure building (*Autodesk*, 2020). *Autodesk Revit* 2023 is one of the BIM-based software that is useful in 3D modeling so that it produces a document needed to design a building, both in terms of structure, architecture, and MEP (Mechanical, Electrical, and Plumbing). In *Revit* modeling, each 2D, 3D, and scheduling drawing sheet represents information from the same virtual building model. As the user works on a building model, *Revit* gathers information about the modeling of the building and coordinates this information across the rest of the modeling representations.

2.5.2. Advantages and Disadvantages of Autodesk Revit 2023

The advantages and disadvantages of using Autodesk Revit 2023 are explained below,

1. Advantages of *Autodesk Revit* 2023
   - Objects Loaded with Technical Information**,** no matter how many times we use the object in the design, the data will be summarized in the *Revit system* such as the quantity, total weight, total material requirements, and the amount of price.
   - Ease of Forming Objects, architects can experiment with uncommon building shapes, Revit will convert these shapes into wall panels, floor panels, and roofs so that the effectiveness of the building will be immediately analyzed by the contractor without having to go through a time-consuming manual drawing process.
   - Reduced Obstacles in Teamwork, Worksharing that Revit brings to ease of working in a team is very useful for medium and large-scale projects. By using this feature accompanied by a computer network, all tasks of each discipline can be integrated virtually. Changes made by one person will be updated in other work units.
   - Revisions That Don't Take Up Much Time, Cost, & Effort, Revit which stands for Revise Instantly means revising instantly. Revisions will have a lot of impact on big projects because they will all be interconnected.
   - Rapid & Precise Drawing Production, The sheets that Revit produces are not separate sheets, but sheets that are integrated.
   - Connections Between Autodesk Software, Output from Revit can be extracted and read well by other Autodesk software.
   - Better Communication with Clients, By using Revit, architects and contractors can present quality displays that represent their designs to clients
2. Disadvantages of *Autodesk Revit* 2023
   - need for high hardware specifications, Like many modern design software, Revit requires adequate hardware specifications to run smoothly, especially when working with large or complex models

- Expensive license prices, Initial investment in Revit licensing can be expensive, especially for small companies or individuals who are just starting out in the industry.
- In its use, new family materials must be made according to the design and size needed

2.5.3. User Interface of Autodesk Revit 2023

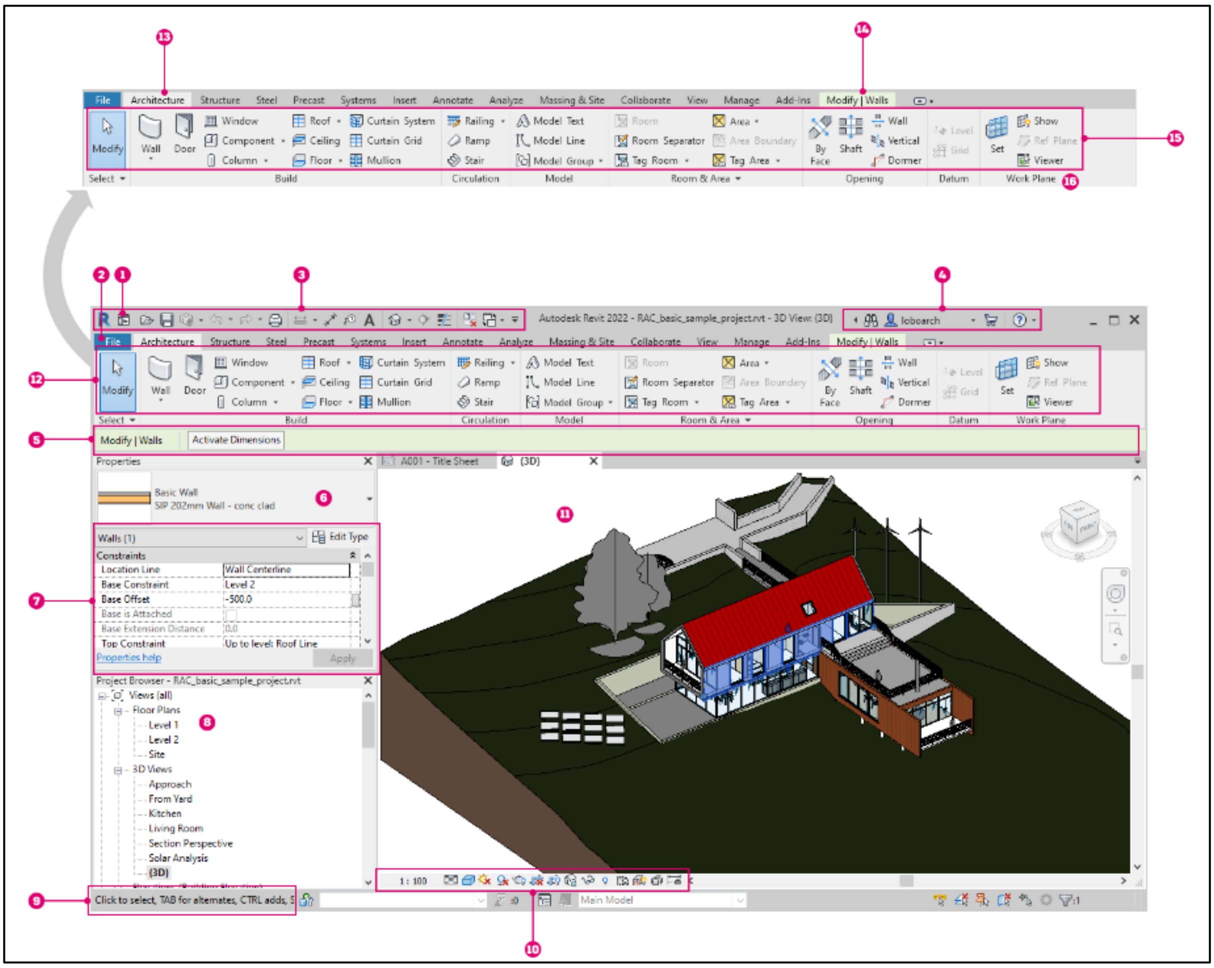

Figure 2.11 User Interface Autodesk Revit 2023

(Source: www.knowledge.Autodesk.com)

Below is an explanation of each part of Interface Autodesk Revit 2023 according to the number listed in **Figure 2.11** above,

1. Revit Home

   Use Revit Home to access and manage information related to your models.

2. File Tab

The File tab provides access to common file actions, such as New, Open, and Save. It also allows you to manage files using more advanced tools, such as Export and Publish.

3. Quick Access Toolbar

   The Quick Access toolbar contains a set of default tools. You can customize this toolbar to display the tools that you use most often.

4. InfoCenter

   InfoCenter provides a set of tools that enable you to access many product-related information sources.

5. Options Bar

   The Options Bar is located below the ribbon. It displays conditional tools dependent on the current tool or selected element.

6. Type Selector

   The Type Selector identifies the currently selected family type and provides a drop-down from which you can select a different type.

7. Properties Palette

   The Properties palette is a modeless dialog where you can view and modify the parameters that define the properties of elements.

8. Project Browser

   The Project Browser shows a logical hierarchy for all views, schedules, sheets, groups, and other parts of the current project. As you expand and collapse each branch, lower-level items display.

9. Status Bar

   The status bar provides tips or hints on what to do. When you highlight an element or component, the status bar displays the name of the family and type.

10. View Control Bar

    The View Control Bar provides quick access to functions that affect the current view.

11. Drawing Area

    The drawing area (canvas) displays views (and sheets and schedules) of the current model. Each time you open a view in a model, the view displays in the drawing area.

12. Ribbon

    The ribbon displays when you create or open a file. It provides all the tools necessary to create a project or family.

13. Tabs on the ribbon

Contains what tabs are on the Ribbon and contains tools that are suitable for their respective functions.

14. A contextual tab on the ribbon, providing tools relevant to the selected object or current action

    Contains tabs that provide tools relevant to the object in the form of an element or component that is currently selected or what is currently being worked on.

15. Tools on the current tab of the ribbon

    the current tab of the ribbon Contains tools that are useful in working and has been grouped by each tab.

16. Panels on the ribbon

    These are the panels that appear on the Ribbon.

CHAPTER III
DESIGN AND PROCEDURE

3.1. DESIGN OF THE RESEARCH

The bridge that will be designed and will be made in 3D modeling is a prestressed concrete bridge using girder beams in the form of PCI-Girder. The bridge to be designed consists of 3 parts, namely, superstructure, substructure, and foundation. The bridge has a length of 40 meters and a width of 10 meters with a superstructure bridge configuration as shown in the picture below.

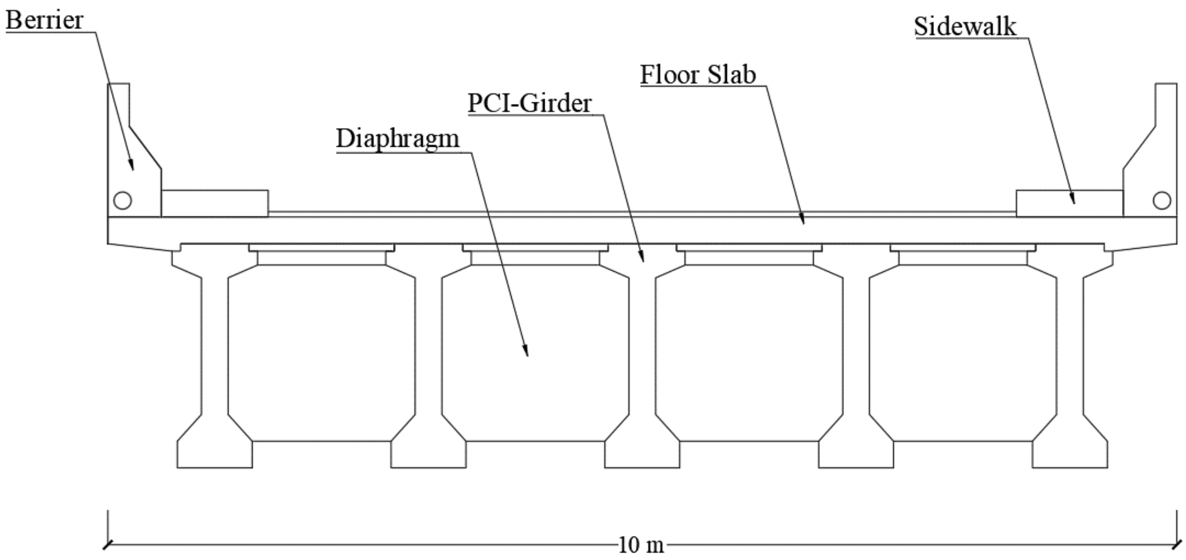

***Figure 3.1** Superstructure Bridge Configuration*

Then here are some criteria that need to be considered in bridge planning, including the following.

1. Rules and guidelines used;
2. Materials/materials used;
3. Methods and assumptions in calculations;
4. Methods and assumptions in determining the type of superstructure,
5. Methods and assumptions in determining the type of substructure and foundation
6. Field data collection;
7. The computer program used; and

8. The method of checking is carried out.

The guidelines used in the planning of this bridge are by the following standards.

1. *SNI 1725 – 2016 Pembebanan Untuk Jembatan;*
2. *SNI 2833 – 2016 Perencanaan Jembatan Terhadap Beban Gempa;*
3. *Panduan Praktis Perencaan Teknis jembatan (No. 02/M/BM/2021)*
4. *Manual Perencanaan Struktur Beton Bertulang Untuk Jembatan (No. 009/BM/2008)*
5. *RSNI T-12-2004 Standar perencanaan struktur beton untuk jembatan;*
6. *SNI 2847 – 2019 Persyaratan Beton Struktural Untuk Bangunan Gedung*
7. *Permen PUPR No.5 Tahun 2023 tentang Persyaratan Teknis Jalan dan Perencanaan Teknis Jalan;*
8. *SNI 8460 – 2017 Persyaratan Perancangan Geoteknik;*
9. *Permen PUPR No. 10 Tahun 2022 tentang Penyelenggaraan Keamanan Jembatan Dan Terowongan Jalan*
10. AASHTO LRFD Bridge Design Specifications 2020
11. Building Code Requirements for Structural Concrate (ACI 318M-14) And Commentary (ACI 318RM-14)
12. FHWA NHI-05-042 Design and Construction of Drive Pile Foundation
13. BMS 92 Bridge Design Code vol 1 dan 2; dan
14. BMS 92 Bridge Manual Design vol 1 dan 2;

3.2. FLOWCHART OF THE RESEARCH

The flowchart of this research can be seen as shown in Figure 3.2 below

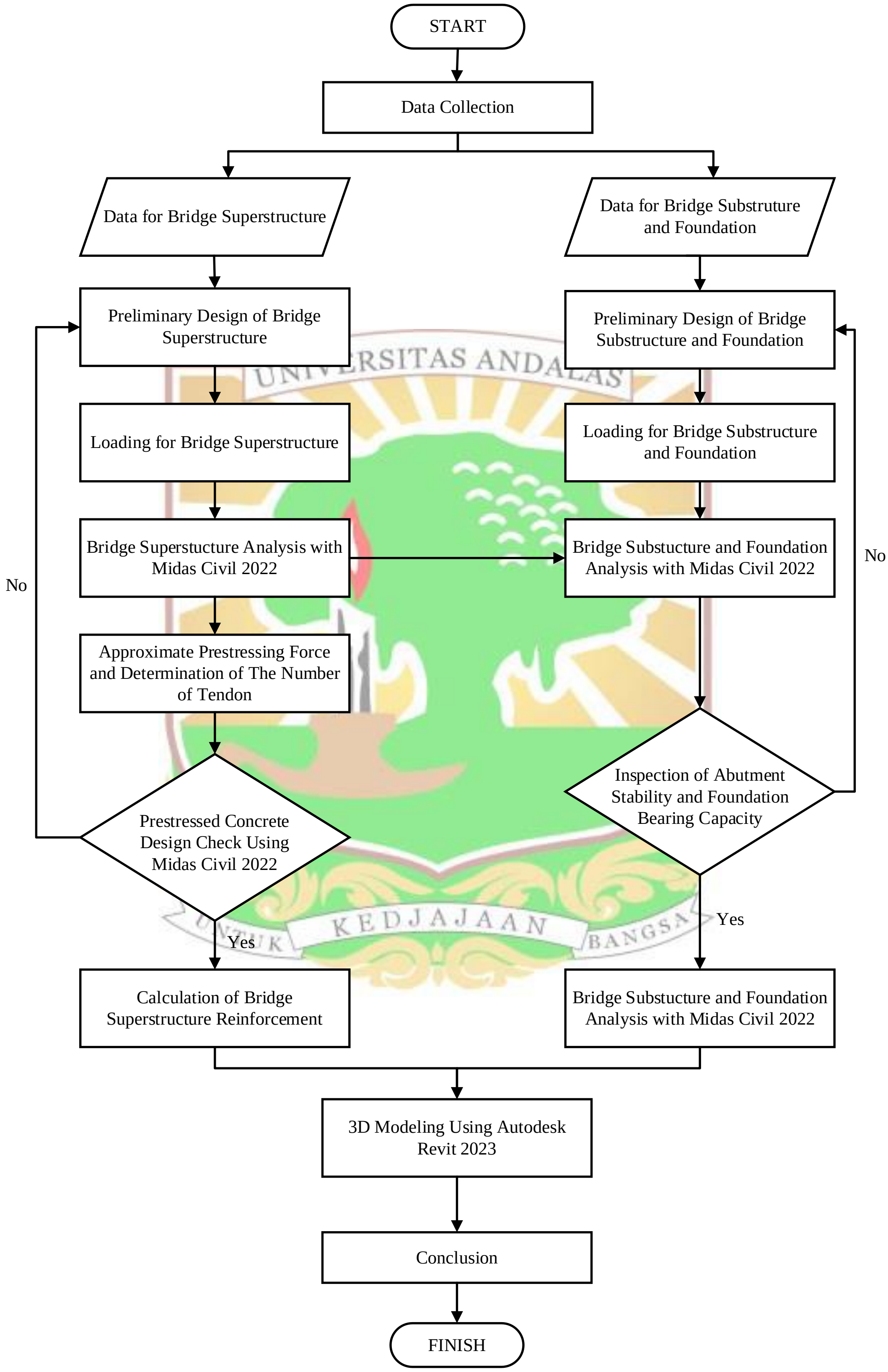

Figure 3.2 *Flowchart of The Research*

3.3. IMPLEMENTATION PROCEDURE

1. Literature Study Stage

   This literature study can be done by searching and studying various information related to the Research work related to prestressed concrete bridges and BIM, both from journals on the internet and the Help feature provided by Midas and *Autodesk* to help understand the use of the *software*.

2. Data Collection Stage

   The data needed for the work of this Research includes Detailed Engineering Design (DED) drawings of various existing Prestressed Concrete bridges (all spans and widths), soil data needed for the planning of the substructure and foundation, and data on bridge planning guidelines according to existing standards.

3. Preliminary Design Stage

   In planning the components of the concrete structure, it is necessary to carry out a preliminary design to determine the initial dimensions of the Superstructure, Substructure, and foundation of the Bridge to facilitate its planning.

4. Structural Analysis Stage of Bridge Structure with Midas Civil 2022

   This stage is useful for getting the Internal force acting on the bridge structure based on the load acting on the bridge. The internal force generated is useful for the stage of approximating prestressed concrete and determining the number of tendons required by the girder beam, the stage of calculating the reinforcement, and the reaction force generated by the superstructure of the bridge will be used as a load to analyze the substructure of the bridge. To assist in the calculation of the force in the analysis of the structure of the Bridge using Midas Civil.

5. Approximate of Prestressed Force and Determination of the Number of Tendons Stage

   Concrete has excellent strength in resisting pressure, but is weak in resisting tension. Therefore, a useful tendon is needed to provide an internal force to the beam to counter the external force received by the beam. Calculations in designing the right tendons can ensure that the structural elements can withstand the load as designed.

6. Design Check Stage on Prestressed Concrete

   Stress checks on prestressed concrete have several crucial uses that support structures' success, safety, and durability. Stress checks help ensure that the stress applied to the tendon is following the design, thus preventing potential structural failure due to improper or excessive stress. The things that are checked at this stage are the inspection of prestressed force loss, the inspection of the allowable stress on concrete, and the inspection of bending and shear capacity. If the value result at this stage is not as allowed, then it is necessary to recalculate the Approximate Prestressed Force and Determination of the Number of Tendons

7. Control Stage of Abutment Stability and Foundation Bearing Capacity

   Control of abutment stability and foundation bearing capacity are two important aspects of bridge planning. The abutment stability ensures that the abutment can safely withstand external loads and forces without experiencing damage or shifting, whereas the foundation bearing capacity is the ability of the soil or base material to support the load passed from the structure to the ground without experiencing failure. If the abutment stability and the foundation bearing capacity do not meet the allowable values, we need to do a preliminary design of the abutment or foundation again.

8. Calculation Stage of Bridge Reinforcement

   The calculation stage of bridge reinforcement is a critical part of the design process to ensure the bridge's safety, stability, and durability. This stage involves detailed structural analysis to determine the loads the bridge will be subjected to and the amount of reinforcement needed to handle those loads.

9. 3D Modeling Stage

   The bridge modeling carried out in this Final Project uses Autodesk Revit 2023, both structural modeling and architecture of each item on the building. This can be done by utilizing the features available in the software used to find out what data and processes can be done in the modeling.

10. Conclusion

   The conclusion from this research is to obtain a Detailed Engineering Design (DED) from the design of a prestressed concrete bridge that can withstand the working load and make a 3D model of the bridge.

CHAPTER IV
FINDING AND DISCUSSION

4.1. DATA COLLECTION

The bridge that will be planned and designed with the implementation of the Building Information Modeling (BIM) concept is a prestressed concrete bridge with a span of 40 meters divided into three main parts, namely the Superstructure, the Substructure, and the Foundation. Planned and designed bridges can be classified based on several categories as follows :

1. According to their function, bridges are classified as highway bridges;
2. According to the material, the bridge is classified as a concrete bridge;
3. According to the classification, bridges are classified as prestressed concrete bridges;
4. According to the structural support system, bridges are classified as simple pedestal bridges; and
5. According to the cut plane, bridges are classified as straight bridges.

4.1.1. Data for Bridge Superstructure

Based on *Kriteria Desain Jembatan Standar* at point 3.2.1.g about *Perencanaan Bangunan Atas Jembatan yang isinya* “If it is not specifically planned, it can be used for buildings on Bina Marga standard bridges (Standard Drawing) according to the economic span and water traffic conditions below such as: Prestressed concrete girder type I span 16 to 60 meters" then with a span length of 40 meters, the building on the bridge is chosen, namely the Prestressed Concrete Bridge using PCI-Girder

Based on Letter of *Bina Marga No.05/SE/Db/2017* concerning “*Kriteria Desain Jembatan Standar”* in point 3.2.1.g concerning “*Perencanaan Bangunan Atas Jembatan*” which reads "If it is not specifically planned, the building on the *Bina Marga* standard bridge (standard drawing) can be used according to the economic span and water traffic conditions below such as Type Prestressed Concrete I-Girder (PCI-Girder) span 16 to 60 meters", then with a span length of 40 meters, the bridge building is chosen, namely the Bridge Prestressed Concrete

Prestressed Concrete Bridge will be planned and designed its Superstructure with the following general data.

1. Type Concrete bridge structure, namely type prestressed concrete type PCI-Girder

2. The track type under the bridge is a river
3. The length of the bridge is 40 meters
4. The bridge to be designed has a width of 10 meters with the division The bridge has 2 lanes with a width of 3.5 meters and has two barriers and a sidewalk on the left and right sides of the bridge with a width of 1.5 meters (0.5 m barrier and 1 meter sidewalk)
5. The barrier has a height of 1.25 meters with a customized shape made of concrete fc'= 30 MPa (Specific gravity = 24 kN/m)
6. The sidewalk has a thickness of 0.25 meters with a customized shape made of concrete fc'= 20 MPa (Specific gravity = 24 kN/m)
7. The wearing surface on the bridge uses asphalt with a thickness of 50 mm (Specific Gravity = 22 kN/m)
8. The diaphragm has a thickness of 0.20 meters with a customized height and width according to PCI-Girder Shape.

Prestressed concrete bridges will be designed using the following material specifications :

1. Beam Girder Material Data

• Compressive Strength of Concrete at 28 Days	f'cg	=	50	MPa
• Compressive Strength of Concrete During Stressing	f'cig	=	0.8 f'cg	MPa
		=	40	MPa
• Modulus of Elasticity of Concrete at 28 Days	Ecg	=	$4700\sqrt{f'cg}$	MPa
		=	33234.02	MPa
• Modulus of Elasticity of Concrete During Stressing	Ecig	=	$4700\sqrt{f'cg}$	MPa
			29725.41	MPa
• Specific Gravity of Concrete	γc	=	25	kN/m^3

2. Floor Slab Material Data

• Compressive Strength of Concrete at 28 Days	f'cd	=	30	MPa
• Compressive Strength of Concrete When First Loaded	f'cid	=	25	MPa
• Modulus of Elasticity of Concrete at 28 Days	Ecd	=	$4700\sqrt{f'cg}$	MPa
		=	33234.02	MPa
• Modulus of Elasticity of Concrete When First Loaded	Ecid	=	$4700\sqrt{f'cg}$	MPa
			29725.41	MPa

- Specific Gravity of Concrete γc = 24 kN/m^3

3. Prestressed Steel Material Data

• Type of Strand	Seven Wire Strand, Low Relaxation			
• Pre-Stressed Steel Grade	ASTM 416-250 (Normal)			
• Diameter of Strand	Dps	=	12.70	mm
• Cross-Sectional Area of Strand	Aps	=	98.71	mm^2
• Tensile Strength of Pre-Stressed Steel	fpu	=	1860	MPa
• Yield Strength of Pre-Stressed Steel	Fpy	=	0.9 fpu	
		=	1674	MPa
• Modulus of Elasticity of Pre-Stressed Steel	Eps	=	197000	Mpa
• Jacking Force	Fbt	=	0.75 fpu	
		=	1395	MPa

4. Steel Reinforcement Material Data

Steel Reinforcement Grade (for D ≥ 13 mm)	: BJTD 42			
• Yield Strength of Reinforcement Steel	fy	=	420	MPa
• Yield Strength of Reinforcement Steel	fu	=	525	MPa
• Yield Strength of Reinforcement Steel	Es	=	200000	MPa
Steel Reinforcement Grade (for D < 13 mm)	: BJTD 24			
• Yield Strength of Reinforcement Steel	fy	=	420	MPa
• Yield Strength of Reinforcement Steel	fu	=	525	MPa
• Yield Strength of Reinforcement Steel	Es	=	200000	MPa

5. Elastomer Bearing Pad (Support)

• Length of Elastomer Bearing	L	=	600	MPa
• Width of Elastomer Bearing	W	=	600	MPa
• Thickness of Elastomer Bearing	H	=	97	MPa
• Shape Factor	S	=	10	
• Compressive Stiffness	SDc	=	1.56E+06	kN/m
• Shear Stiffness	SDs	=	3.85E+03	kN/m
• Allowable Compressive Strength	Pn	=	4220	kN

4.1.2. Bridge Substructure Data

The main function of the building bridge Substructure is to channel all the loads acting on the bridge Superstructure to the foundation or ground. The substructure to be planned and designed has the following general data.

1. The river that passes under the bridge has a calm current and does not sink under drifting objects so that it does not affect the load on the substructure too much or can be considered non-existent.
2. The soil parameters used to analyze the substructure have the following data.
   - Specific Gravity of Soil γ_{soil} = 22 kN/m^3
   - Angle of Internal Friction ϕ = 30°
   - Cohesion of Soil C = 10 kN/m^2
3. The material of the substructure used has the following data.
   - Compressive Strength of Concrete f'c = 30 MPa
   - Steel Reinforcement Grade for D ≥ 13 mm BJTD 42
   - Steel Reinforcement Grade for D < 13 mm BJTP 24

4.1.3. Foundation Data

The foundation is the part of the bridge that passes the load directly to the soil or rock. The type of foundation used is determined based on soil conditions in the form of NSPT data. The NSPT data used in the foundation design are shown in the figure below.

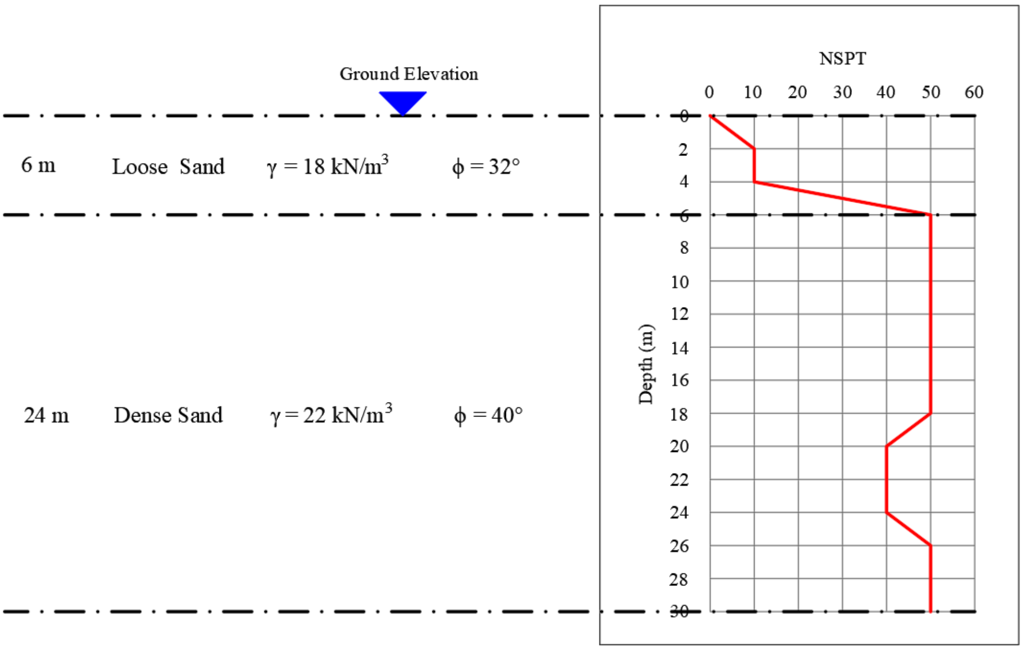

***Figure 4.1** Soil Layer and Soil Data*

Based on the data seen in the image above, the soil surface has soft soil and soil depth with sufficient bearing capacity at a depth of 6 meters. According to FHWA NHI-05-042 Design and Construction of Driven Pile Foundation, page 7-4, the type of foundation that matches the soil conditions is the pile foundation. The data from the pile foundation used is as follows.

1. The material of the foundation used has the following data.
   - Compressive Strength of Concrete f'c = 30 MPa
   - Steel Reinforcement Grade for D ≥ 13 mm BJTD 42
   - Steel Reinforcement Grade for D < 13 mm BJTP 24
2. The dimensions of the pile foundation used have the following data.
   - Diameter of Foundation D = 0.8 m
   - Depth of Foundation H = 15 m

4.2. DESIGN OF BRIDGE SUPERSTRUCTURE

4.2.1. Preliminary Design of Bridge Superstructure

Based on Table 4.1 concerning *tinggi minimun struktur atas* in *Panduan Praktis Perencanaan Teknis Jembatan Volume 2* (2021), the initial height of the deck system for the simple span Prestressed Concrete I-Girder Bridge is 0.045L, where L is the length of the bridge,

- Bridge Length L = 40.00 m
- Minimum Height of Deck System hd = 0.045 . L mm
  = 1800 mm

To determine the spacing between girders, the thickness of the plates and the number of girders used can refer to table 3.6.2.2.2b-1 in *Peraturan Perencanaan Teknik Jembatan Bagian 3* (2017). Based on table 3.6.2.2.1-1 in *Peraturan Perencanaan Teknik Jembatan Bagian 3* (2017) The bridge to be designed is included in type k, so :

- The spacing between girders (Sg) should not be less than 1100 mm and should not be more than 4900 mm (1100 mm ≤ Sg ≤ 4900 mm), then in this case, The spacing between girders used is 2000 mm
- The thickness of the floor slab (ts) used must not be less than 110 mm and must not be more than 300 mm (110 mm ≤ Sg ≤ 300 mm), then the thickness of the floor slab used is 250 mm

The length of the cantilever plate on the outer side of the exterior girder (de) is determined based on Table 3.6.2.2.2d-1 i.e. $-300 \leq de \leq 1700$, then the length of the cantilever plate used is 1000 mm. So, from the above requirements, the initial dimensions of the girder and the dimensions of the bridge cross-section are determined as follows:

- Type of PCI-Girder Used PCI-Girder 2100 mm
- Spacing between girders S_g = 2000 mm
- Length of Cantilever Plate De = 1000 mm
- Thickness of the floor slab t_s = 250 mm
- Number of Girder used n_g = 5
- Width of Highway W_t = 7000 mm
- Thickness of diaphragm t_d = 200 mm

Detailed drawings of the Bridge cross-section and girder dimensions are shown in the following figure:

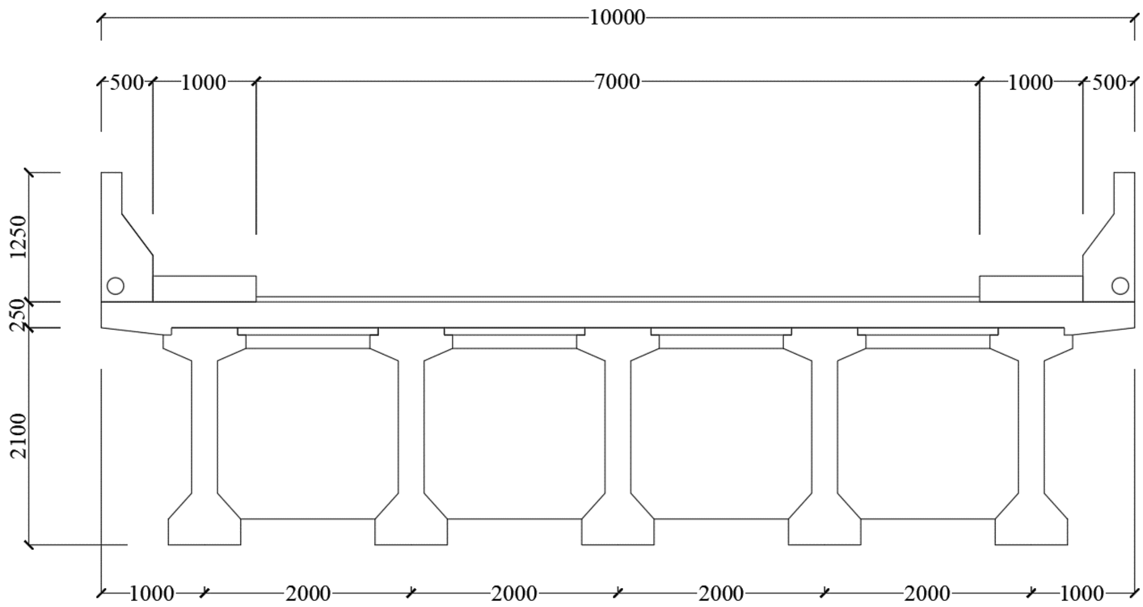

Figure 4.2 *Bridge Cross Section*

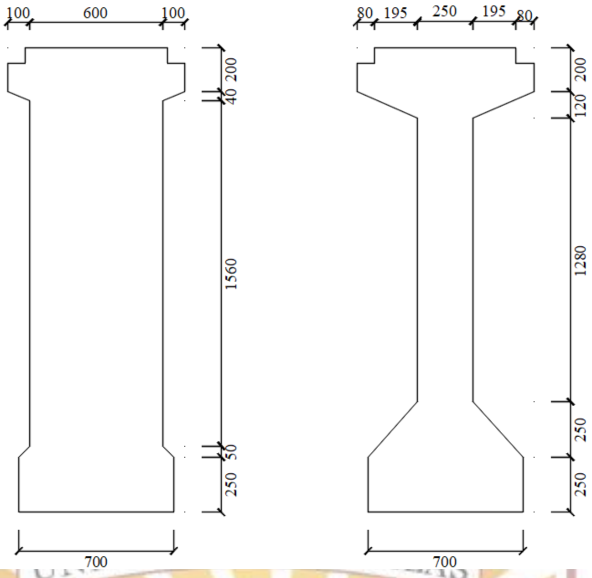

Figure 4.3 *PCI-Girder Cross-Section Dimensions*

4.2.2. Structural Analysis of Superstructure Using Midas Civil 2022

The stages that can be carried out in the analysis of the Superstructure using Midas Civil 2022 include the following.

1. Open Midas Civil 2023 which has been installed on your PC so that the initial display appears as shown below, then select New Project to create a new worksheet.

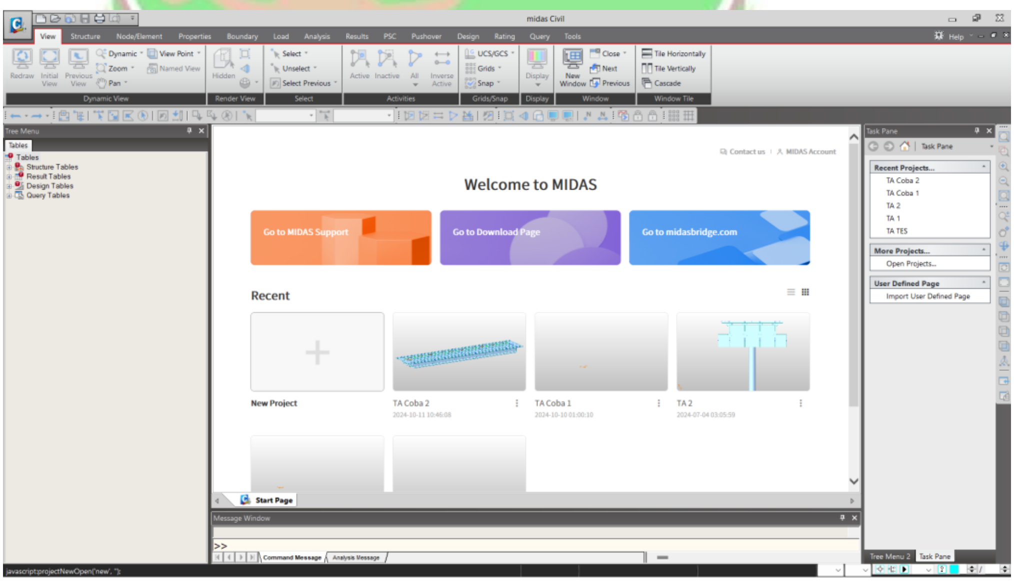

Figure 4.4 *Initial view Midas Civil 2022*

2. Define the material to be used in the modeling of prestressed concrete bridges that have been mentioned in the previous superstructure data, for example, fc'50 and fc'30 concrete, by selecting Properties > Material > Material Structure from the Main Menu As shown in the picture below.

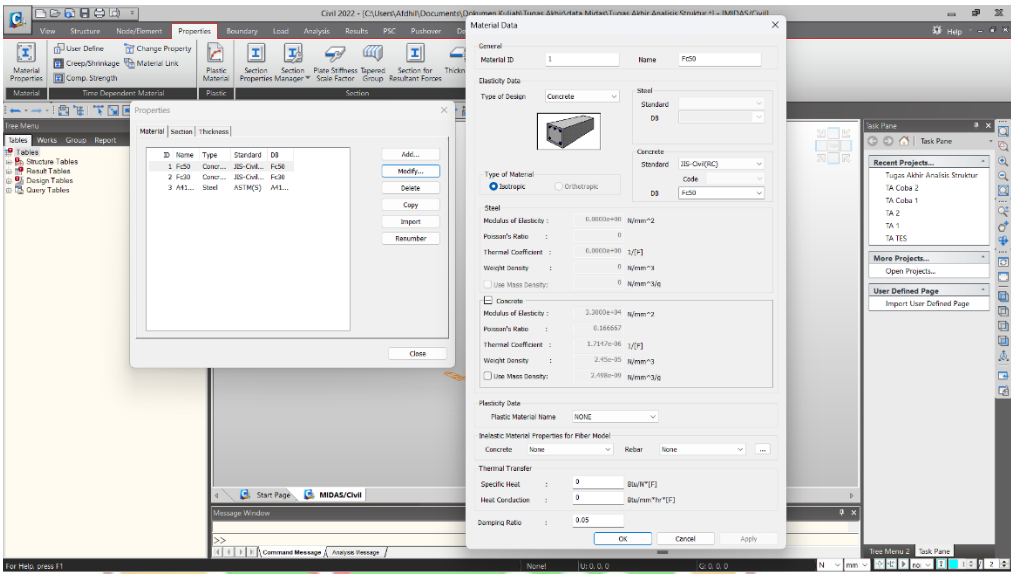

Figure 4.5 *Material Properties*

3. The compressive strength of concrete will increase as the age of the concrete increases since the concrete is poured, therefore we need to define it in all concrete materials that are previously defined following ACI 209R-92 by selecting Properties > Time Dependent > Comp. Strange from the Main Menu Then input the following data:

Compressive strength factor of concrete	a	=	4
	b	=	0.85

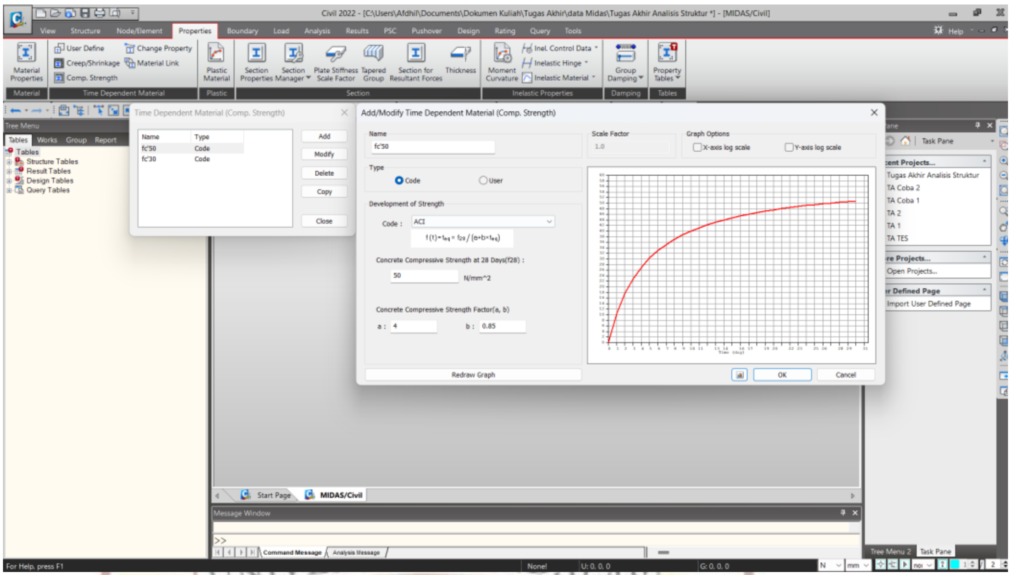

Figure 4.6 *Time-Dependent Material (Comp. Strength)*

4. Because concrete over time will expand and shrink, therefore we need to define the Creep and Shrinkage of concrete in Midas Civil 2022 according to the ACI-209.2R-08 Guideline adjusted according to RSNI T-12-2004 by selecting Properties > Time-Dependent Material > Creep/Shrinkage from the Main Menu and filling in the data in the Creep/Shrinkage Time-Dependent Material (Creep/Shrinkage) dialog box with the following data.

• Relative humidity of ambient environment	H	=	70	%
• Volume surface ratio	d	=	150	mm
• Slumb	s	=	75	mm
• Fine aggregate percentage	F	=	50	%
• Air content	AC	=	6	%
• Cement content	C	=	409	Kg/m^3

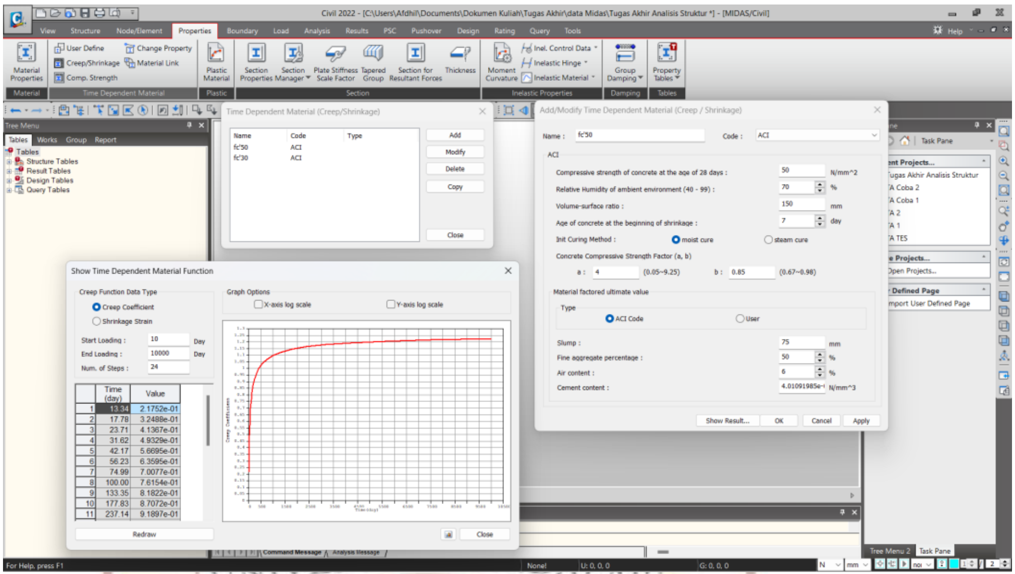

Figure 4.7 *Time-Dependent Material (Creep/Shrinkage)*

5. Then connect the predefined Materials with Comp, Strength, and Creep/Shrinkage data by selecting Properties > Time-Dependent Material > Material link from the Main Menu, as in the picture below.

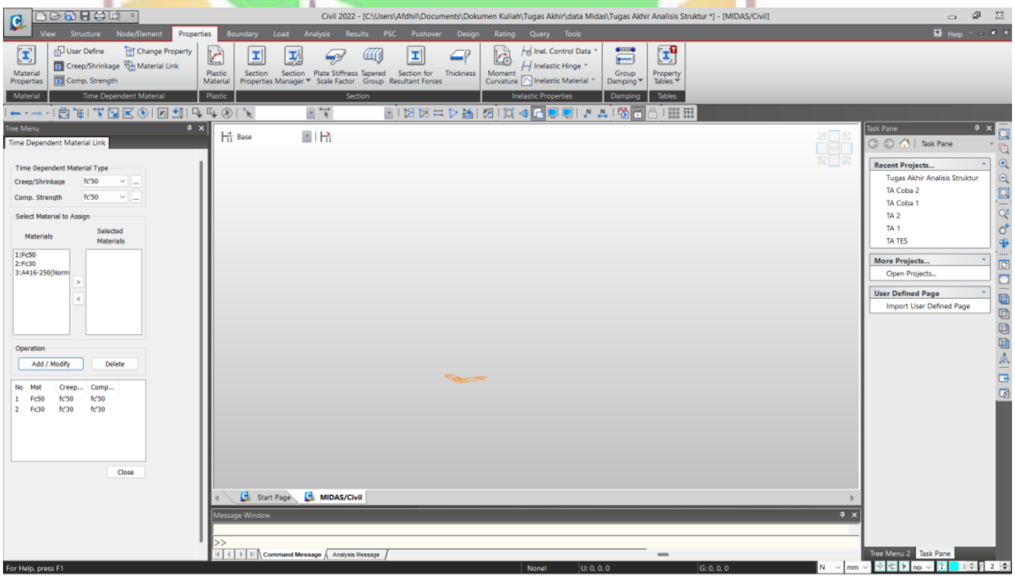

Figure 4.8 *Time-Dependent Material (Material Link)*

6. After the material is defined, the next step is to define the Section Properties by selecting Properties > Section > Section Properties from the Main Menu As shown in the figure below, then define the cross-section of the PCI-Girder, Diaphragm, and Bridge Floor Slab that has been obtained through the previous preliminary design.

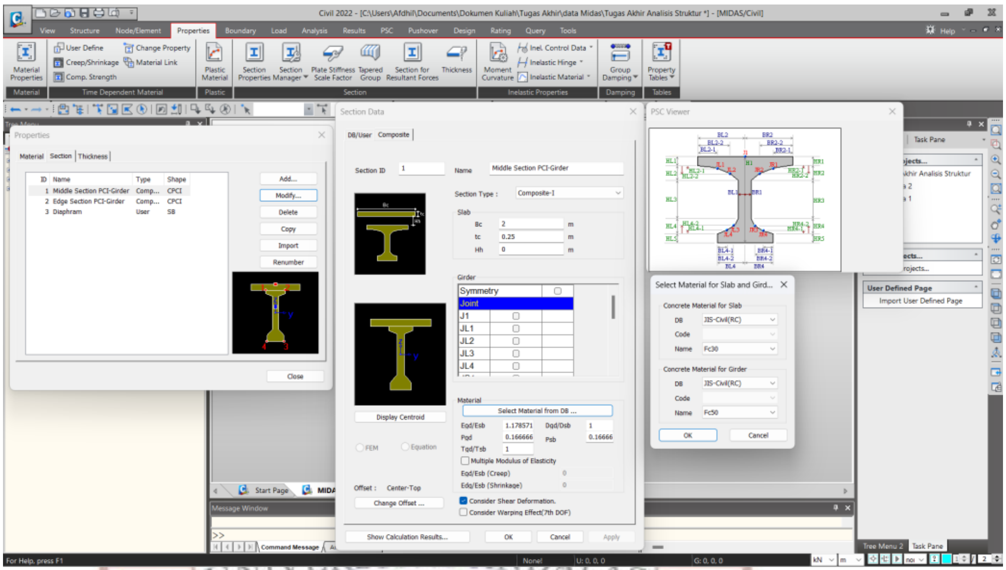

***Figure 4.9** Section Properties*

7. Before starting modeling and loading the structure, we must first choose the type of structure that is the bridge by selecting Structure > Type> Structure Type from the Main Menu. In the Structure Type, select 3-D and then Check Convert Self-Weight into Masses, select Convert to X, Y, Z, and leave the other settings as the initial settings as shown in the figure below.

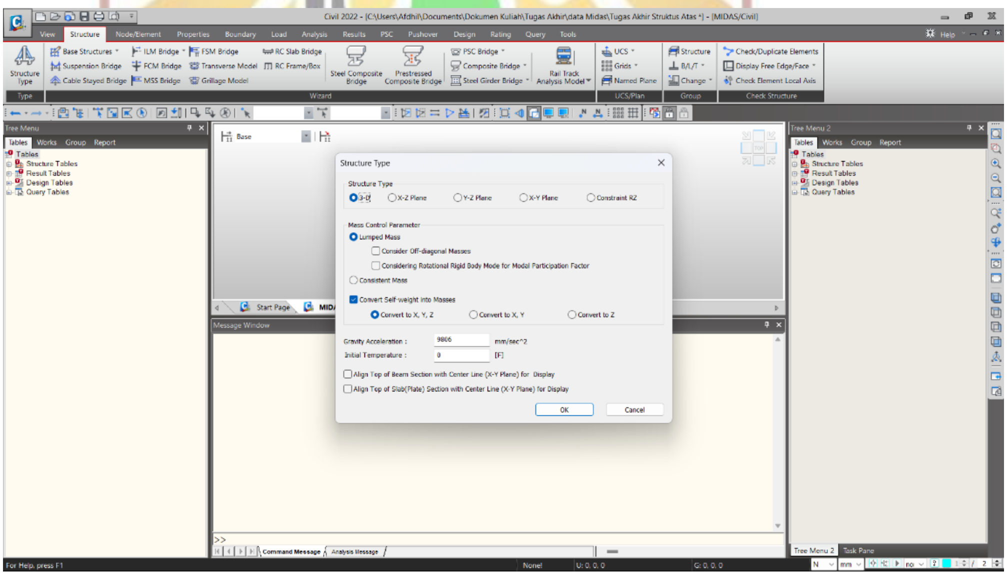

***Figure 4.10** Structure Type*

8. Next, Model and load the bridge with the Wizard feature that has been provided by Midas Civil 2022 which is useful for modeling bridges by selecting Structur e> Wizard > Prestresses Composite Bridge from the Main Menu as in the figure below.

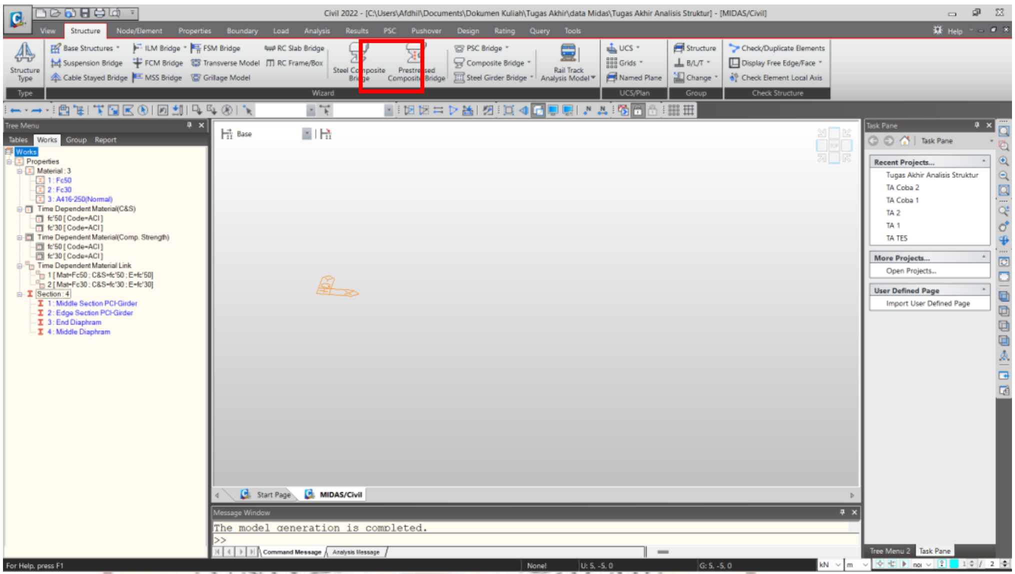

***Figure 4.11** Prestresses Composite Bridge*

9. After the Pre/Post-Tension Composite Girder Bridge Wizard dialog box appears, on the layout page fill in the bridge data such as bridge length, bridge pedestal, and others according to the data we obtained earlier as in the figure below.

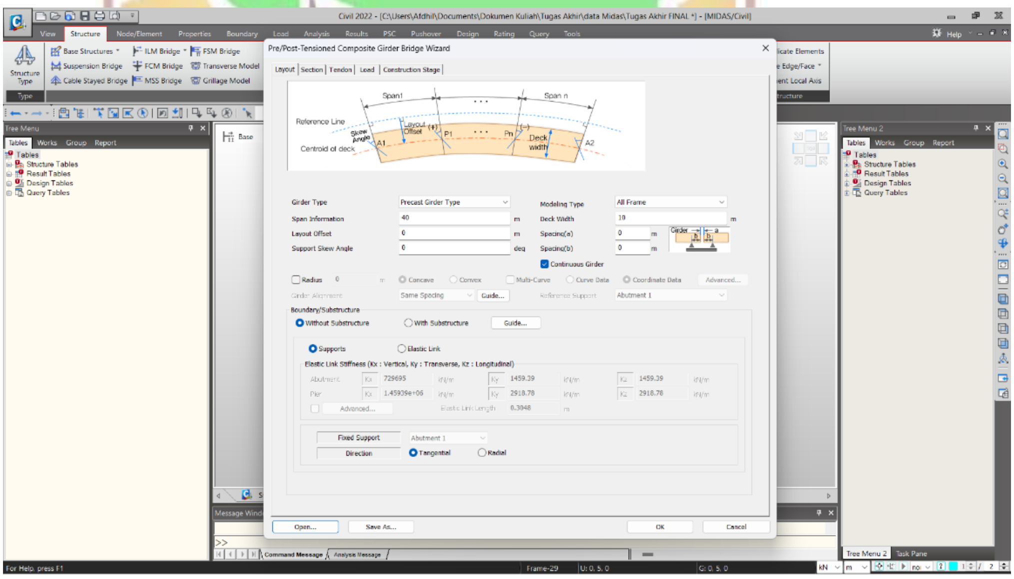

***Figure 4.12** Prestresses Composite Bridge (Layout)*

10. Next, for the Section page in the Pre/Post-Tension Composite Girder Bridge Wizard dialog box, fill in the next data such as deck thickness, the material used for each cross-section, diaphragm data, number of girders and spacing between girders used according to the data that has been obtained previously as in the figure below.

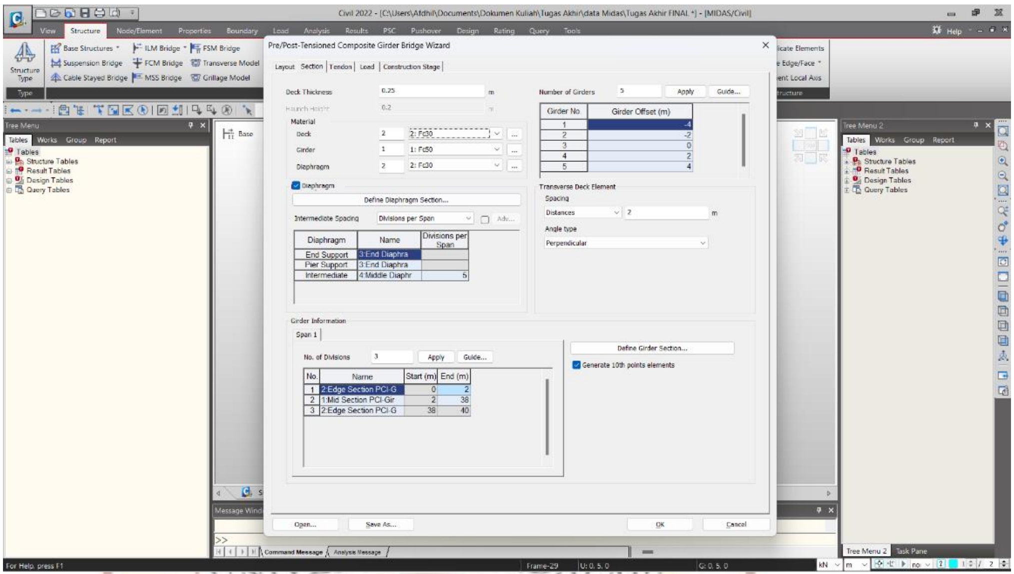

Figure 4.13 *Prestresses Composite Bridge (Section)*

11. For the tendon page is skipped first because the number of tendons used is calculated after the structural analysis is generated and followed by the load page, fill in all the loads that may act on the bridge such as dead loads, live loads and traffic loads according to the guidelines used as shown in the figure below.

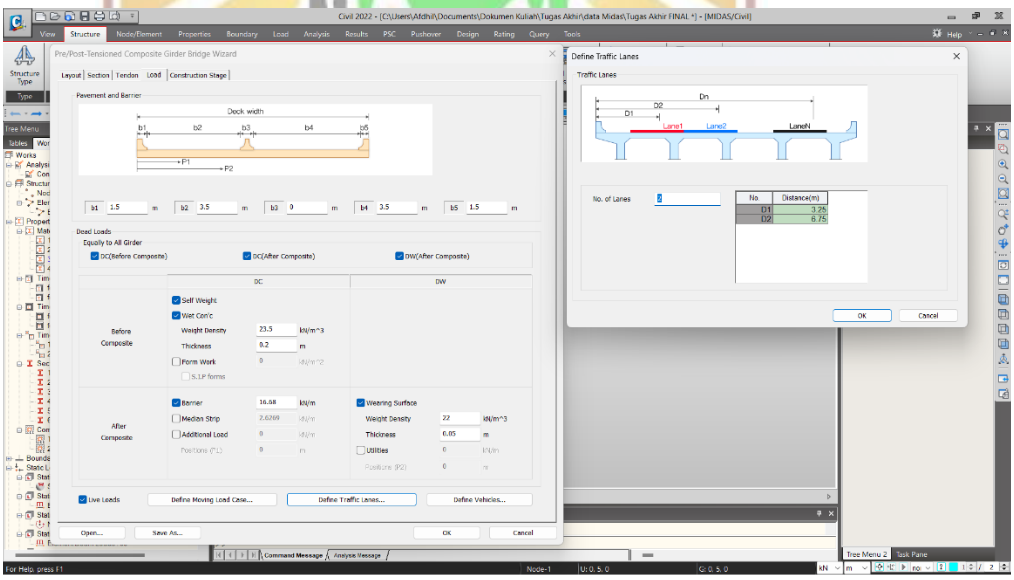

Figure 4.14 *Prestresses Composite Bridge (Load and Define Traffic Lines)*

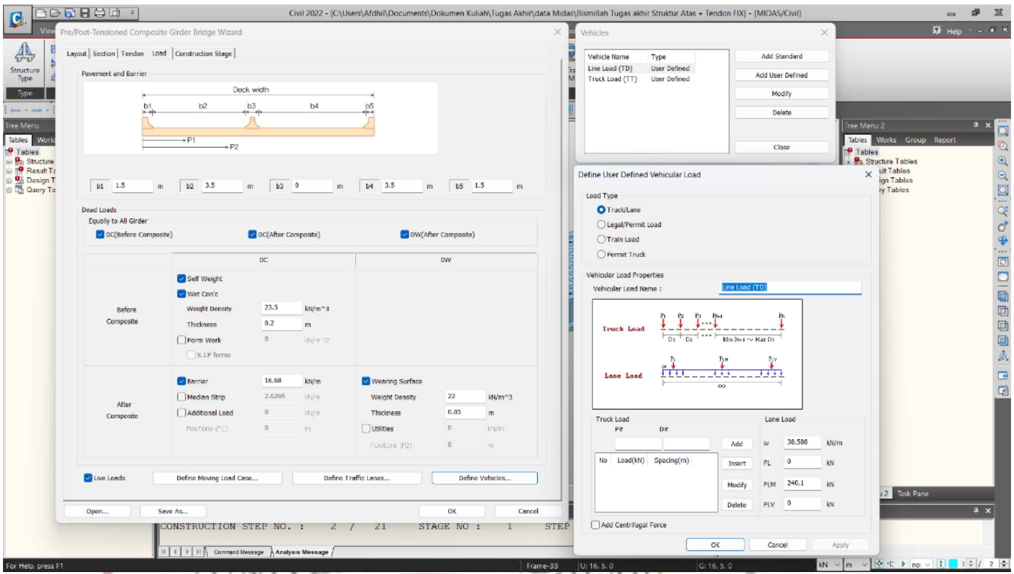

Figure 4.15 *Prestresses Composite Bridge (Load and Define Vehicles)*

12. Then for the Construction Stage page, adjust the construction stages as shown in the figure below.

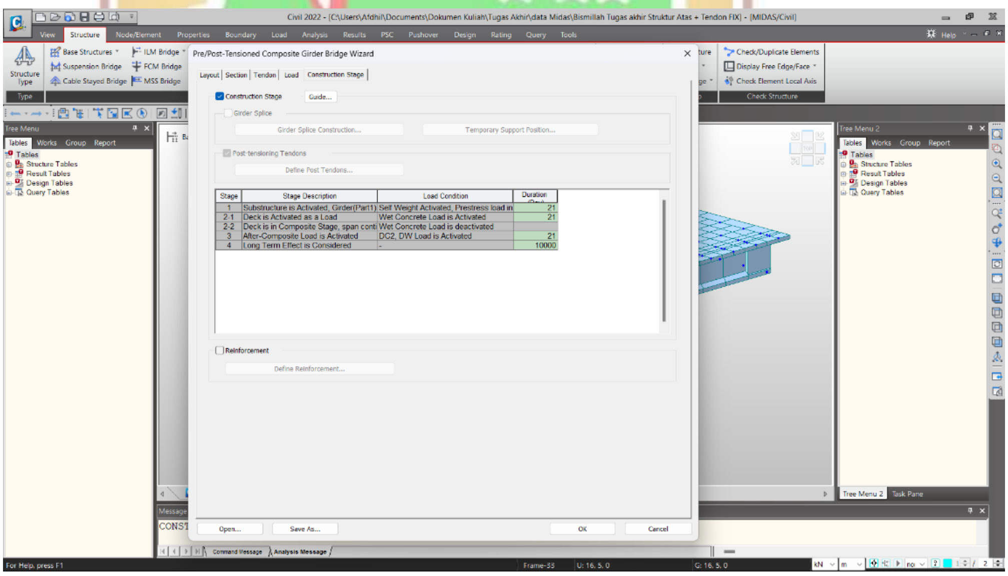

Figure 4.16 *Prestresses Composite Bridge (Construction Stage)*

13. Then the results of the bridge modeling will look like in the figure below.

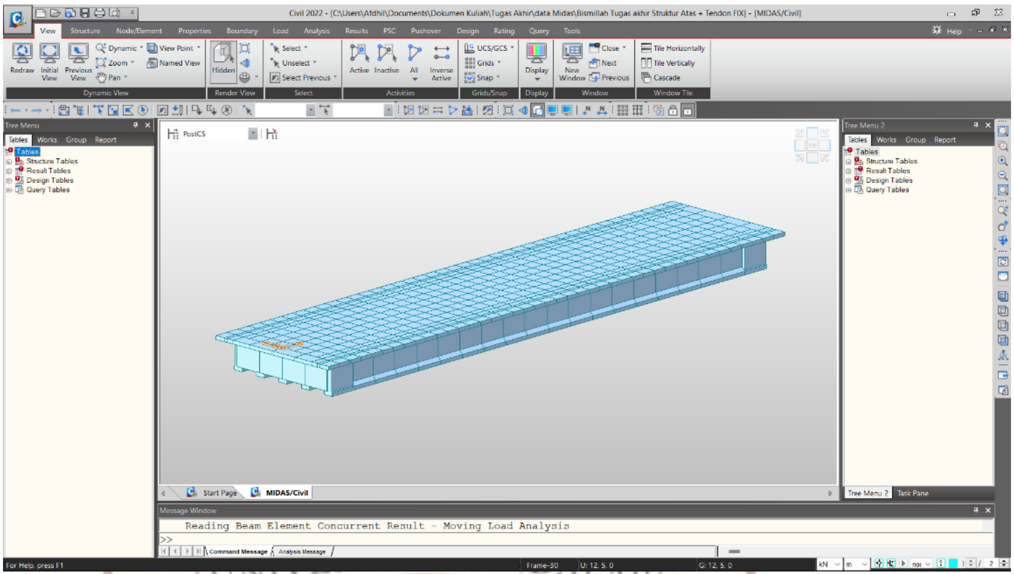

Figure 4.17 *Modeling Results of Prestresses Composite Bridge*

14. Next, Define a Moving Load Case by selecting Load > Load Type > Moving Load > Moving Load Analysis Data > Moving Load Case from the Main Menu, then adjust the Moving Load Case as shown in the figure below.

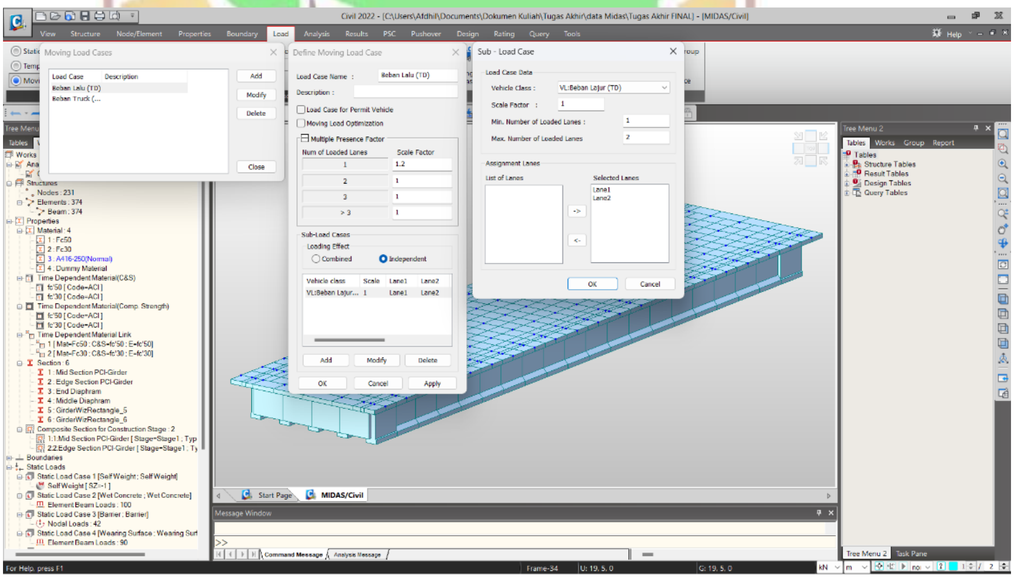

Figure 4.18 *Moving Load Case*

15. Then make adjustments to the Static Load Cases from the results of the Prestresses Composite Bridge that have been made previously and also add Static Load Cases for the loads that will be added next such as Pedestrian Load and Wind Load on Structure by selecting Load > Load Type > Static Load > Create Load Cases > Static Load Cases from Main Menu as in the figure below.

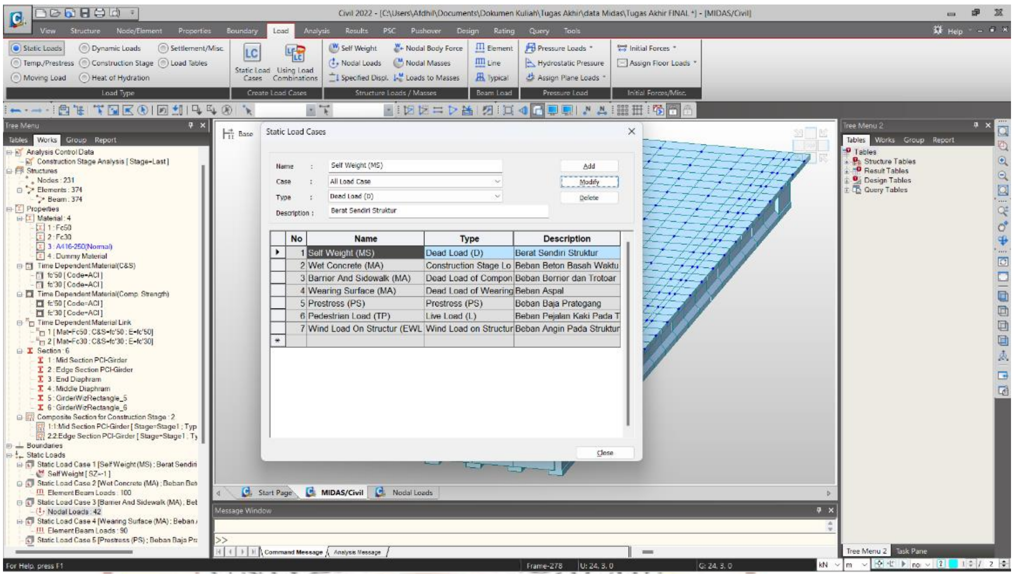

***Figure 4.19** Static Load Cases*

16. Add a pedestrian load of 5 kPa (SNI 1725:2016) by selecting Load > Load Type > Static Load > Structure Load / Masses > Nodal Loads from the Main Menu As shown in the figure below. Because the pedestrian load is the load area while the input is the nodal Load, then convert the pedestrian load as calculated below.

Pedestrian Load	W_{TP}	=	5.00	kN/m^2
Width of Sidewalk	b_{tr}	=	1.0	m
Distance Between Nodes	D_n	=	2.00	m
Point Load on the Central Node	P_{n1}	=	WTP x btr x Dn	
		=	10.00	kN
Point Load on the Edge Node	P_{n2}	=	0.5 x P_{n1}	
		=	5	kN

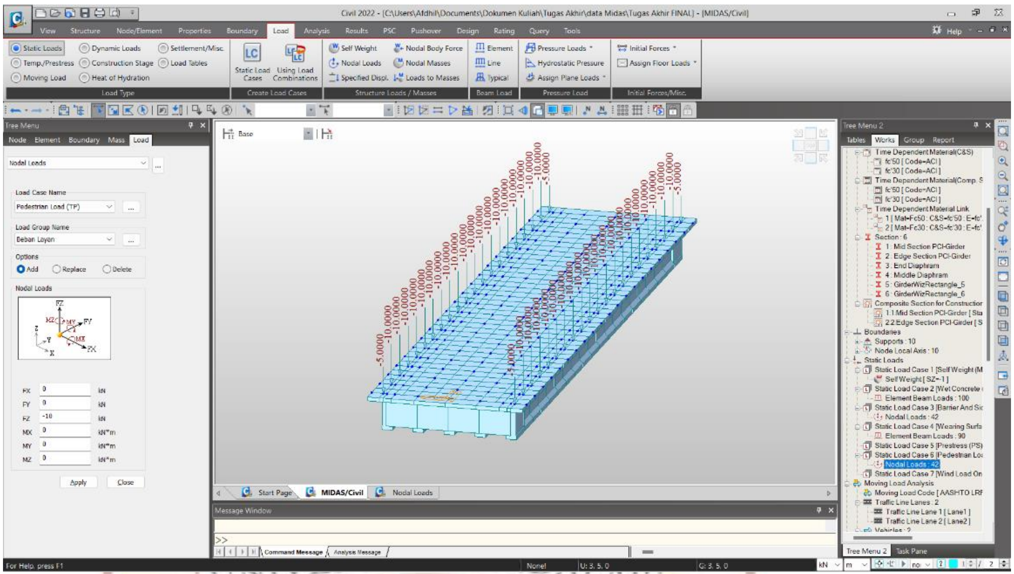

Figure 4.20 *Pedestrian Load*

17. Then add the wind load to the structure which is a uniform load on the outermost girder by selecting Load > Load Type > Static Load > Beam Element > Element from the Main Menu as shown in the figure below. The amount of wind load on the structure is entered based on the data below.

Upstream Surface Conditions	Open Field			
Wind Friction Speed	V_0	=	13.2	km/jam
Length of Friction Upstream of the Bridge	Z_0		70	mm
Elevation of Structures Above Ground	Z	=	9000	mm
Wind Speed Design of 10000 mm above Ground	V_B	=	90	km/jam
Wind Speed at an Elevation of 10000 mm above Ground	V_{10}	=	90	km/jam
Base Wind Pressure	P_B	=	0.0024	MPa
Wind Speed Design	V_{DZ}	=	160.264	Km/jam
Wind Load on Structures	EW_L	=	$P_B\ (V_{DZ} / V_B\ )^2$	
		=	7.610	kN/m

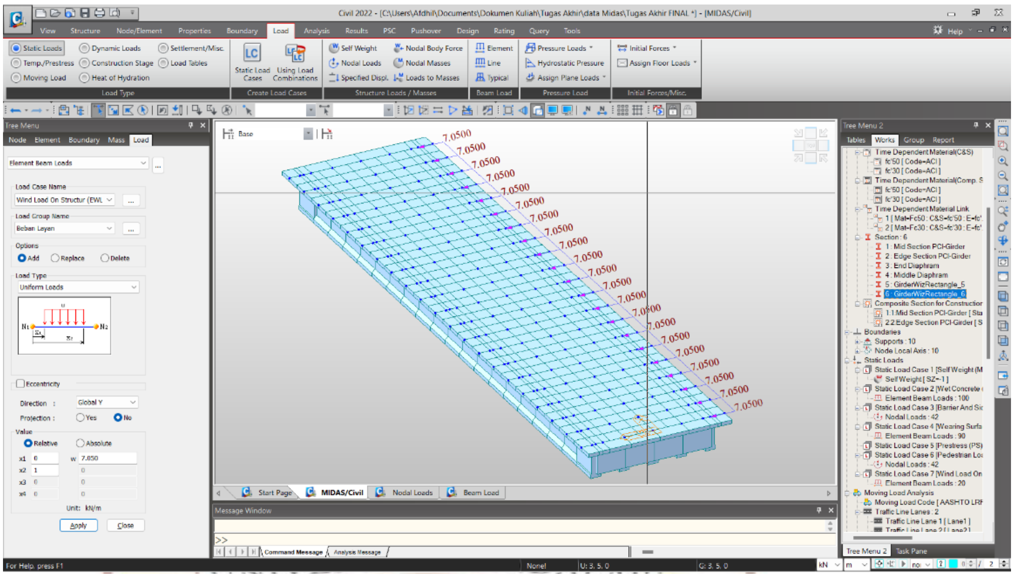

Figure 4.21 *Wind Load on Structure*

18. As a static analysis control on a structure, define the Eigenvalue by selecting Analysis > Analysis Control > Eigenvalue from the Main Menu as shown in the figure below.

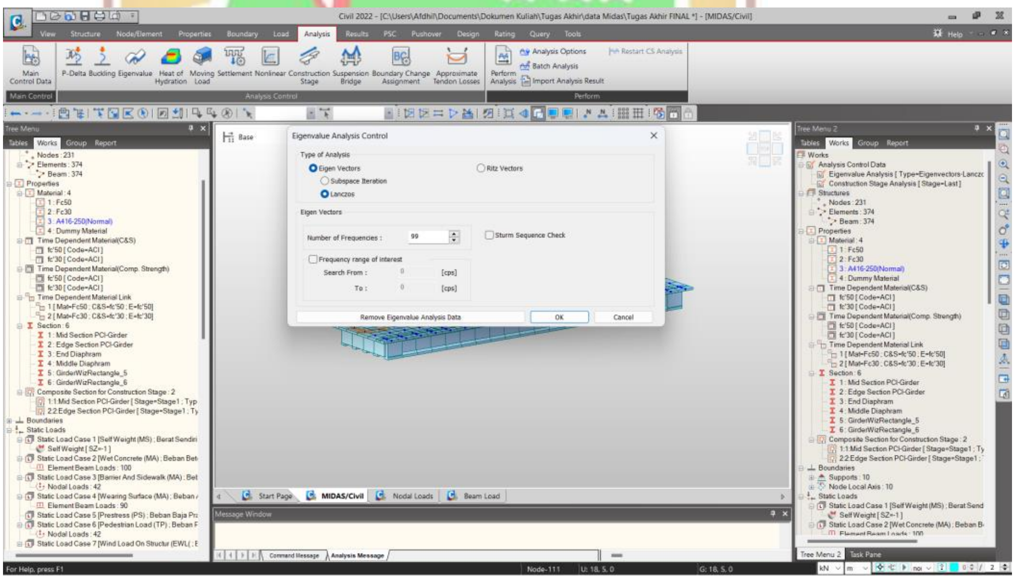

Figure 4.22 *Eigenvalue*

19. Add the earthquake load Response Spectrum, from which the earthquake data is taken from Aplikasi Lini, by selecting Load > Load Type > Dynamic Load > Respon Spectrum > RS Load from the Main Menu as shown in the figure below.

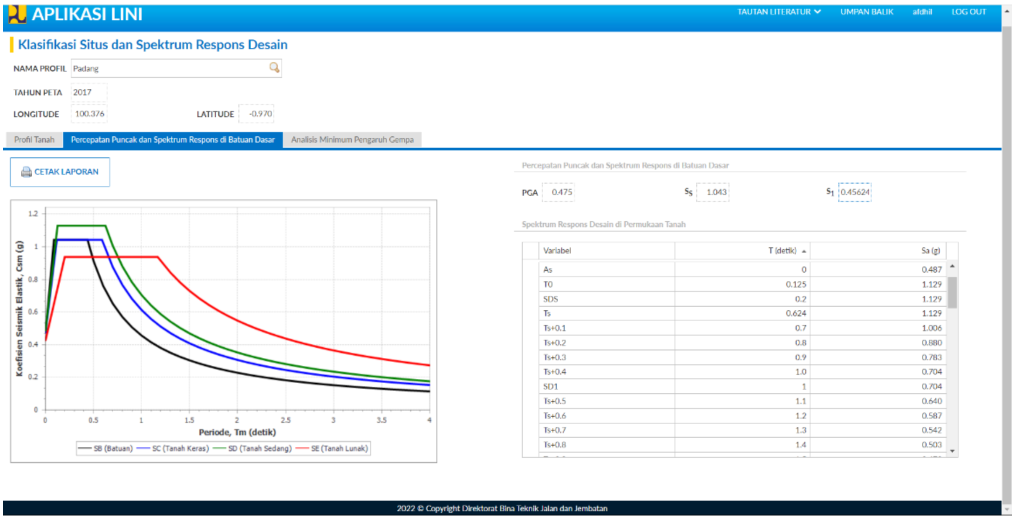

Figure 4.23 Aplikasi Lini

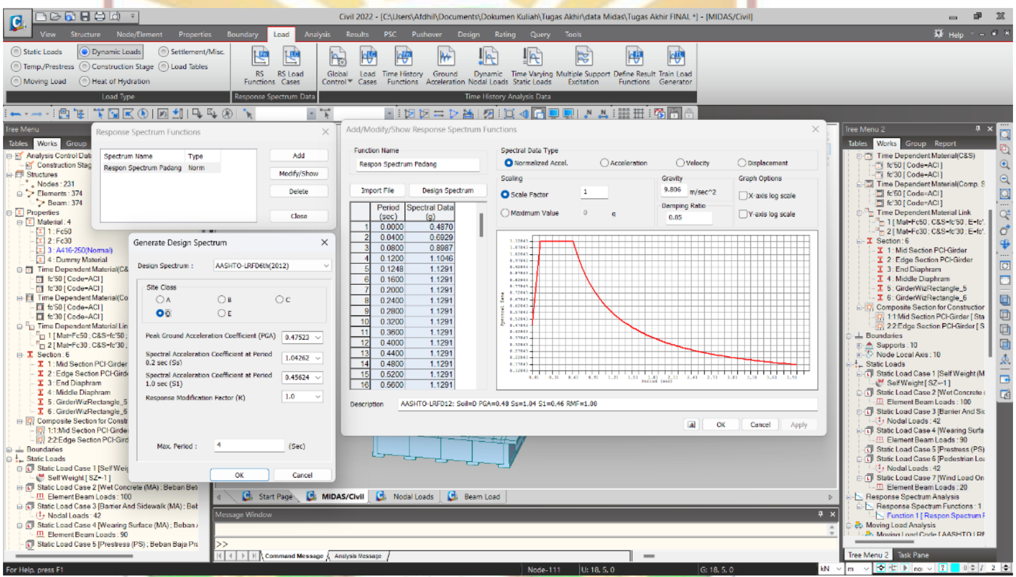

Figure 4.24 Response Spectrum

20. Followed by creating the Load Case Response Spectrum by selecting Load > Load Type > Dynamic Load > Response Spectrum > RS Load Cases from the Main Menu as shown in the figure below.

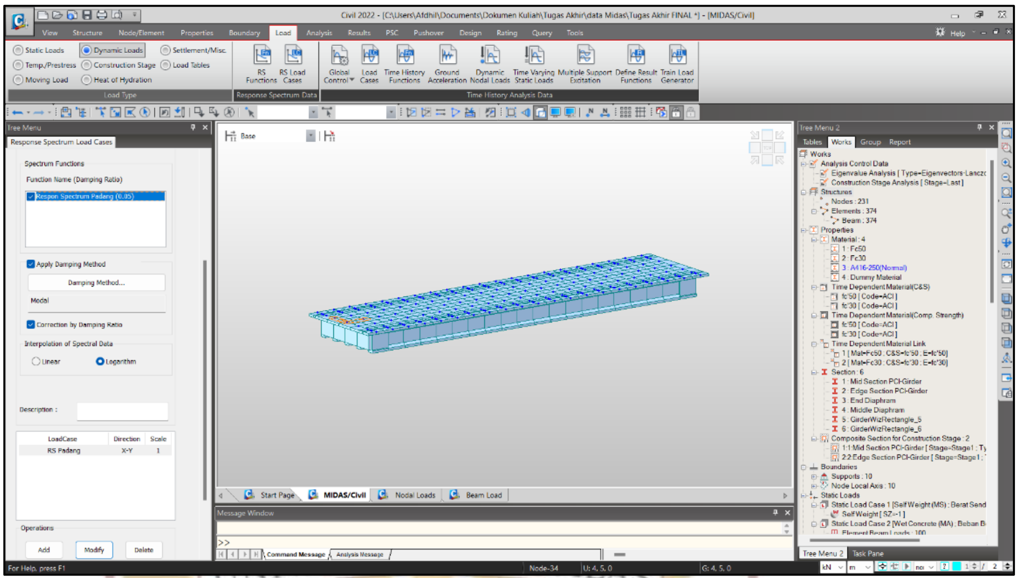

***Figure 4.25** Response Spectrum Load Case*

21. Then make a load combination according to SNI 1725:2016 by selecting Result > Combination > Load Combination from the Main Menu. In this Load Combination, we can create a Load Combination automatically with Auto Generation following the guidelines provided by Midas Civil 2022 such as AASHTO-LRFD17 and adjusted again with SNI 1725:2016 as shown in the figure below

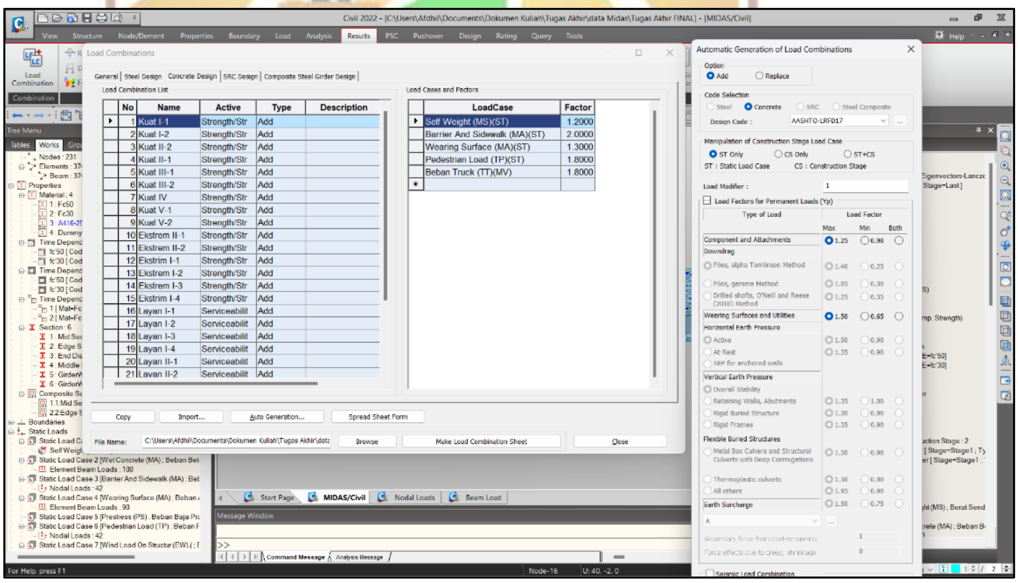

***Figure 4.26** Load Combination*

22. Finally, analyze the bridge structure that has been modeled earlier by selecting Analysis > Perform > Perform Analysis from the Main Menu or you can press the F5

key, then all the results of the analysis can be seen in the Result menu as shown in the figure below.

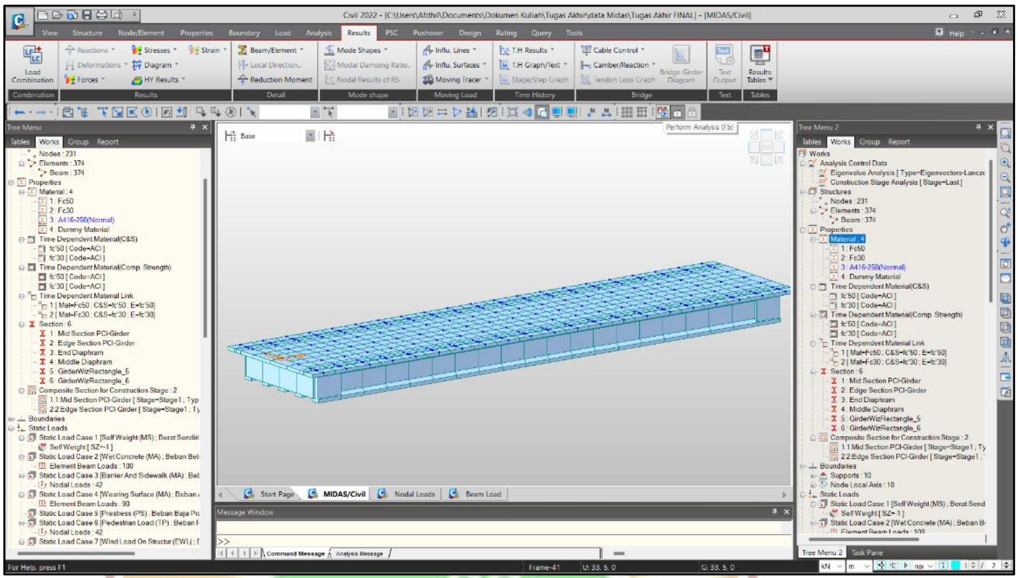

Figure 4.27 *Perform Analysis*

4.2.3. Approximating Prestressing Force and Determination of The Number of Tendon

The number of prestressed strands required is usually determined based on the tensile stress on the bottom fiber (f_{bserv}) of the girder due to the combination of Service III loading, where the amount of tensile stress on the bottom fiber due to the combination of Layan III load based on the analysis using Midas Civil 2022 is:

$f_{bserv} = 20.807$ MPa

The limitation of concrete tensile stress immediately after the transfer of prestressed force that occurs during the service load (f_{alserv}) based on SNI 2847-2019 is:

$$falserv = 0.5\sqrt{fc' \text{ MPa}} = 3.536 \text{ MPa}$$

Thus, the required strand prestressed stress (fpb) at the bottom of the girder is:

$fpb = f_{bserv} - f_{alserv} = 17.271$ MPa

The location of the center of the prestressed force is assumed to be about 5-15 percent of the height of the girder measured from the bottom side of the girder. And in this case, it was chosen by 10 percent.

Distance from the Neutral Axis to the Bottom Fiber	y_b	=	1034.038 mm		
Distance From The Center of the Prestress to The Bottom Fiber	y_{bs}	=	0.1 h_g	=	210.000 mm
Eccentricity at The Mid-Span	e_c	=	y_b - y_{bs}	=	824.038 mm

The stress at the base of the girder due to the effective prestress force, Pe, can be determined by the following equation:

$$Pe = \frac{f_{pb}\ A_g\ S_b}{S_b + e_c\ A_g} = 5503.332 \text{ kN}$$

To calculate the final prestress force on each strand, estimating the prestress losses that occur in the strand is necessary. It is assumed that the prestress losses are 20% and the initial prestress tension is 0.75fpu so the effective prestress is 55%. Then the final prestress force per strand (Pe_strand) can be determined based on the following equation:

$$P_{e\_strand} = A_{strand}\ .\ f_{pbt}\ .\ (1 - \text{losses}) = 110.160 \text{ kN}$$

Based on the calculation above, the number of strands required (Nstr_req) to bear the load acting on the prestressed concrete is:

$$N_{str\_req} = \frac{p_e}{p_{e\_strand}} = 50 \text{ strand}$$

Nstr = 57 strand

N = 3 Tendon

It should be noted that the determination of the initial number of strands can differ from the number of final strands used. For example, in this example, the number of strands required is 50, but in the final condition, 57 strands are used. This is because the initial strand in this example is determined based on the conditions in the middle of the span. However, in segmental prestressed girder bridges, planning is often determined by conditions at the point where there should be no tensile stress at the girder joint so that the number of final strands is more than the initial estimate.

$$A_{ps} = N_{str}\ .\ A_{strand} = 5922.600 \text{ mm}^2$$

4.2.4. Position of Tendon

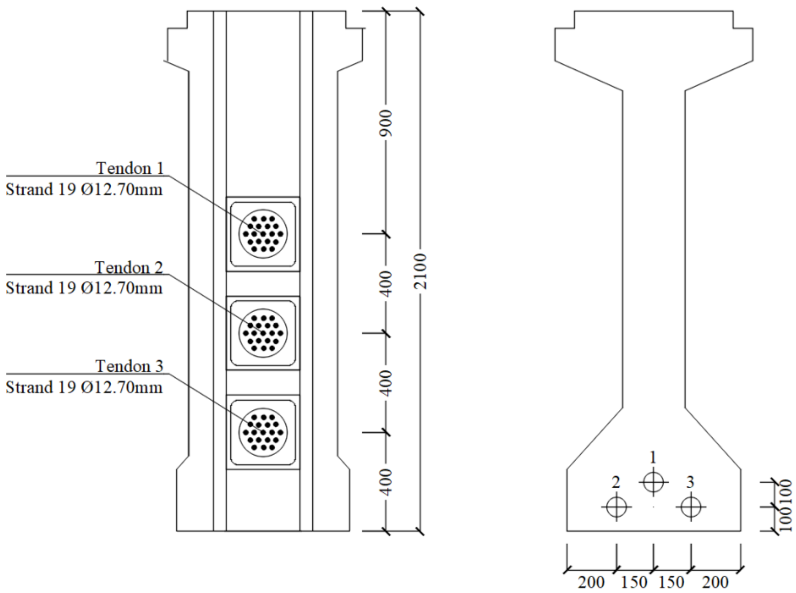

Figure 4.28 *Position of Tendon*

Table 4.1 *Position of Tendon*

Tendon Number	Tendon Code	Number of Strands	Tendon Position in the end of the pan (mm)		Tendon position in the middle of the Span(mm)		Distance of end position and Mid (mm)	
			Yi	Zi	Yj	Zj	ΔY	ΔZ
1	T1	19	0	1200	0	250	0	950
2	T2	19	0	800	150	100	-150	700
3	T3	19	0	400	-150	100	150	300

4.2.5. Prestressed Concrete Design Check Using Midas Civil 2022

Design check on prestressed concrete has some very important uses such as guaranteeing structural safety by ensuring that the concrete elements can withstand the planned load without experiencing failures such as cracking or collapsing. In addition, design checks also ensure optimal performance, so that the structure functions according to its intended purpose, including rigidity and stability over its lifetime. The design inspections that Midas Civil can accommodate are the inspection of prestressed force loss, the inspection of the allowable stress on concrete, and the inspection of bending and shear capacity.

The stages that can be carried out in the check of prestressed concrete design at Midas Civil include the following.

1. By continuing the modeling from the structural analysis that has been done previously, define the tendon data according to the data from the design calculations that have been done previously by selecting Load > Load Type > Temp./Prestress > Prestress Loads > Tendon Property from the Main Menu as shown in the figure below.

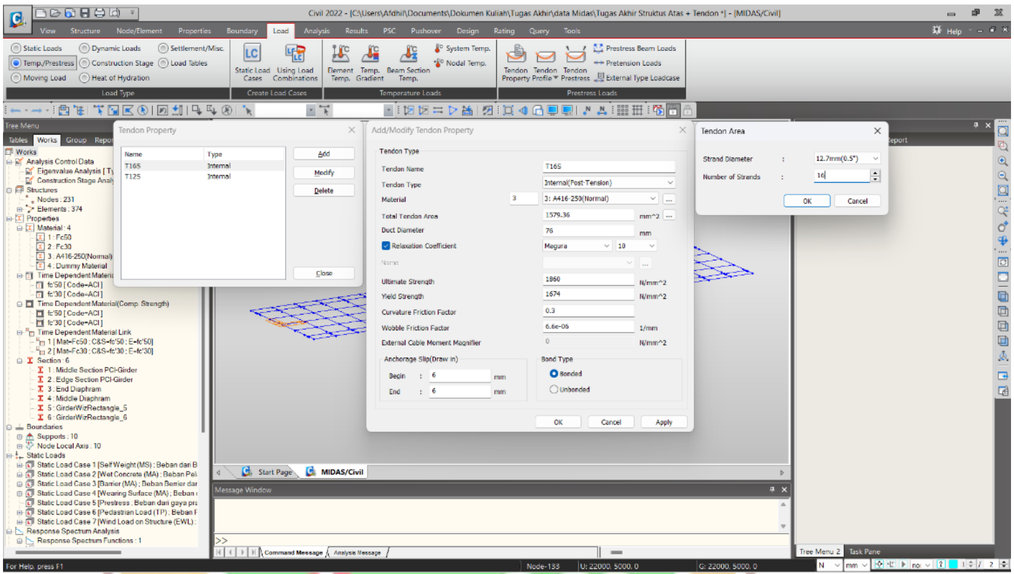

Figure 4.29 *Tendon Property*

2. Define the tendon profile along the span of the girder beam according to the previously calculated data by inputting the coordinates of the tendon at the end of the span and the middle of the span for all girder beams by selecting Load > Load Type > Temp./Prestress > Prestress Loads > Tendon Profile from the Main Menu as shown in the figure below.

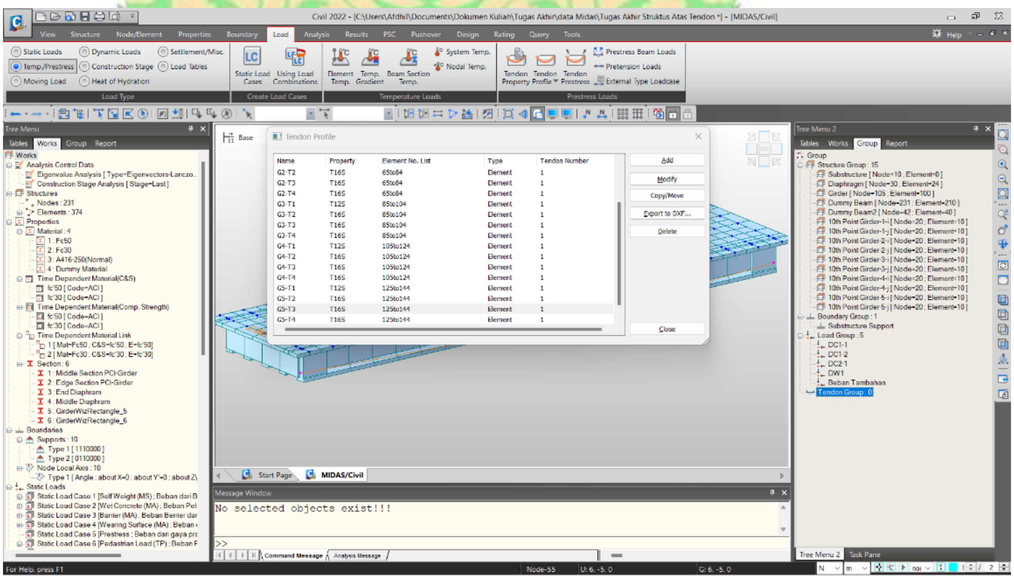

Figure 4.30 *Tendon Profile*

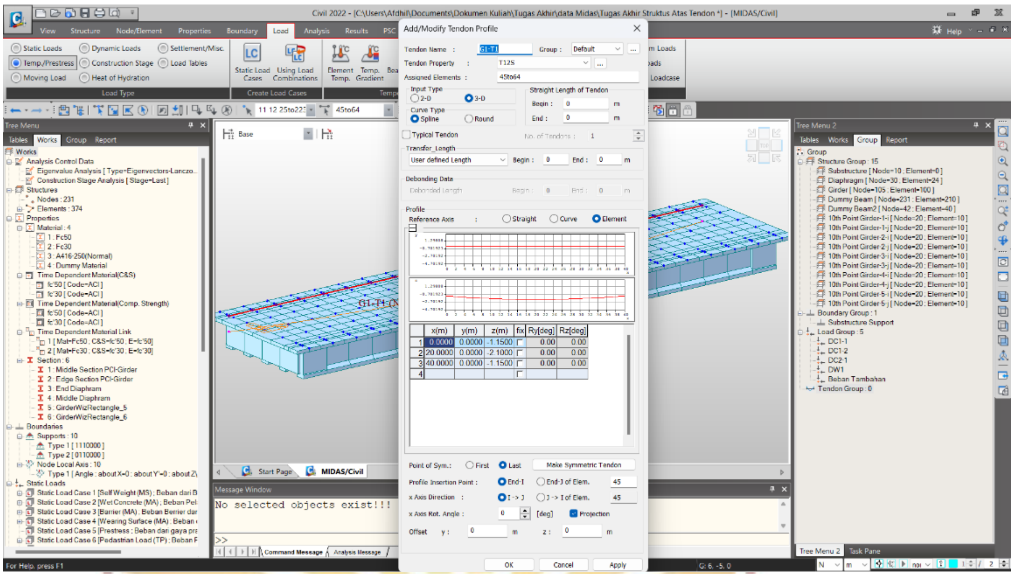

Figure 4.31 *Add/Modify Tendon Profil*

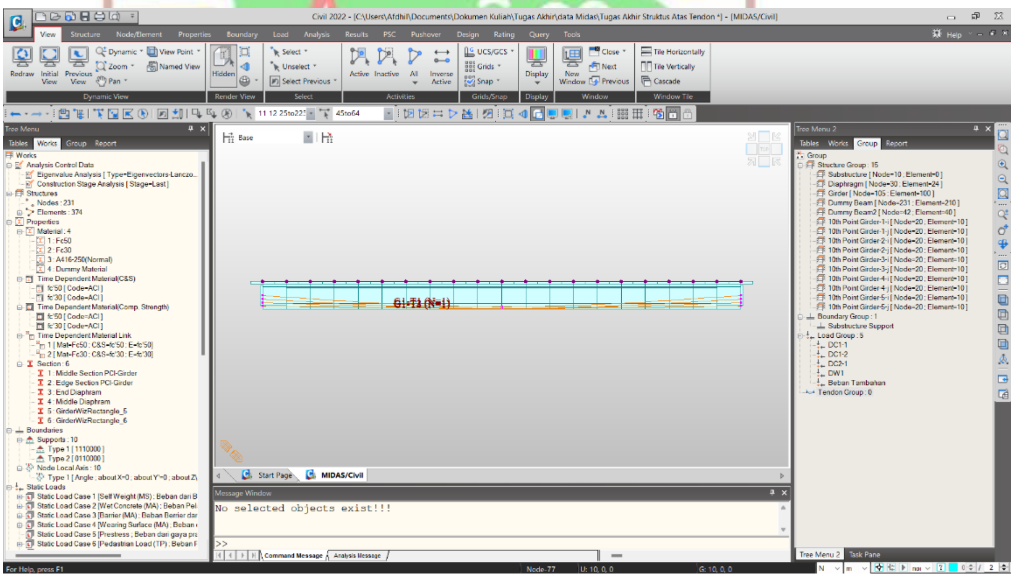

Figure 4.32 *Results from Tendon Profile (Side View)*

3. Define the prestressed load to be applied to the tendon by selecting Load > Load Type > Temp./Prestress > Prestress Loads > Tendon Prestress from the Main Menu as shown in the figure below.

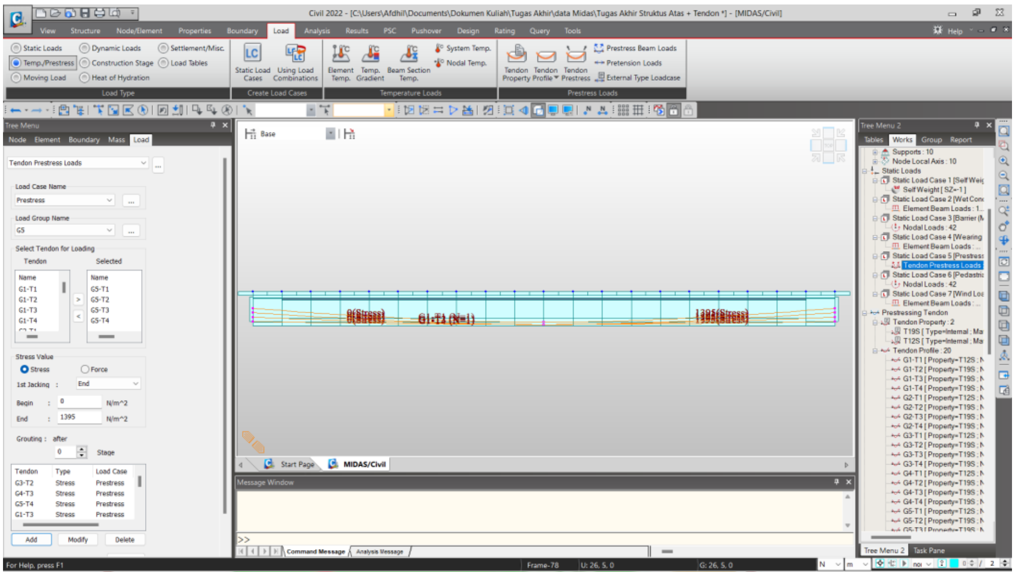

Figure 4.33 *Tendon Prestressed*

4. Add the force acting on the tendon in the Construction Stage in Stage 1 i.e. on the tendon force transfer by selecting Load > Load Type > Construction Stage > Construction Stage Data > Define C.S from the Main Menu as shown in the figure below.

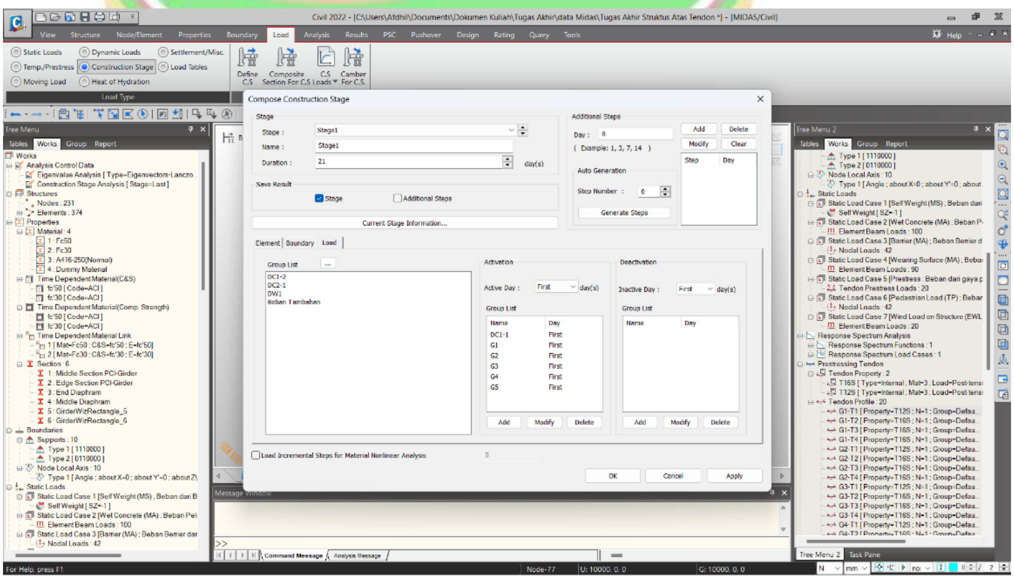

Figure 4.34 *Construction Stage*

5. For checking the flexure capacity and shear capacity of the cross-section, we must include longitudinal reinforcement and shear reinforcement which will be used by the trial and error method until the value of bending capacity and shear capacity follows the allowed value by selecting Properties > Section > Section Manager > Reinforcement from the Main Menu as shown in the figure below.

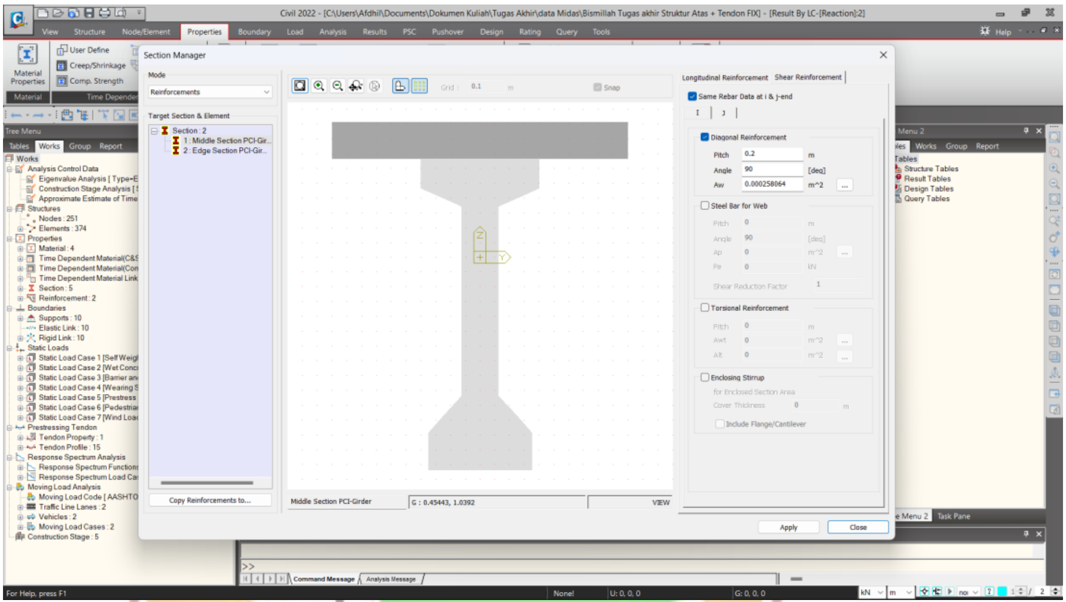

Figure 4.35 *Section Manager (Reinforcement)*

6. To approximate the stress loss in the tendon we must first define the control analysis by selecting Analysis > Analysis Control > Approximate Tendon Losses from the Main Menu as shown in the figure below.

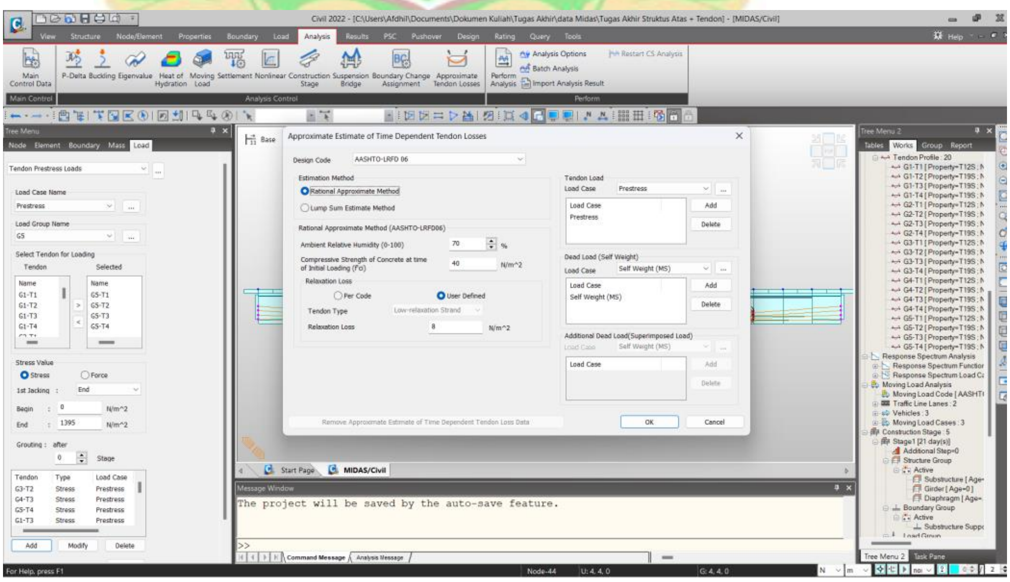

Figure 4.36 *Approximate Tendon Losses*

7. Add a force that works on the tendon in the Load Combination by selecting Result > Combination > Load Combination from the Main Menu as shown in the figure below.

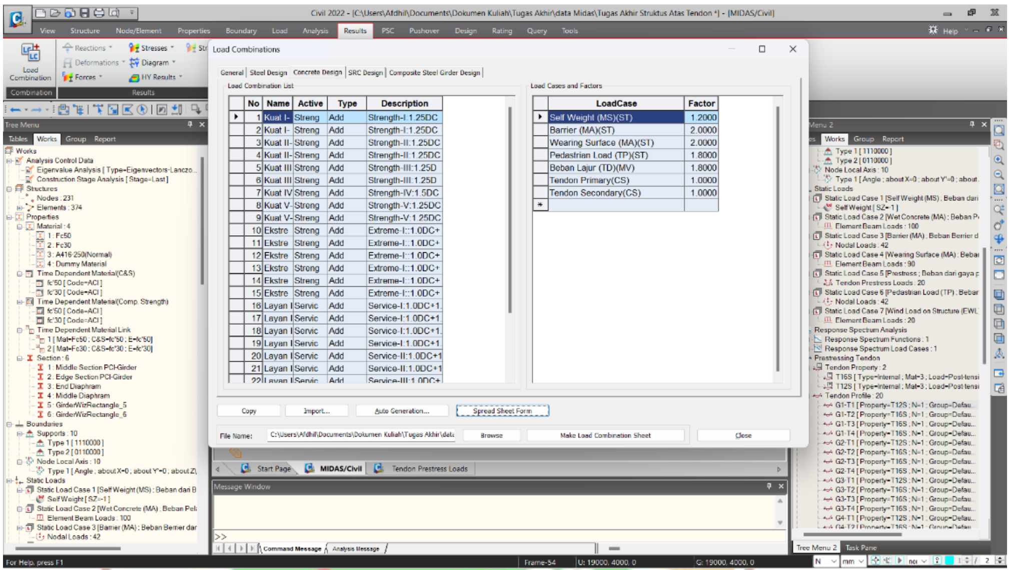

Figure 4.37 *Load Combination*

8. To see the force working on the structure after the Tendon is added, perform a Run Analysis Again by selecting Analysis > Perform > Perform Analysis from the Main Menu as shown in the figure below.

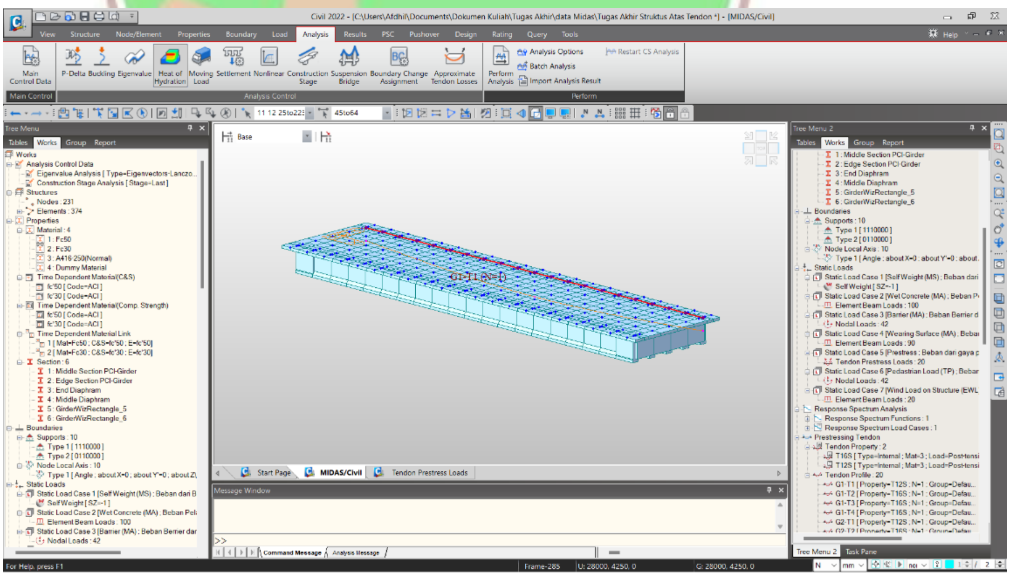

Figure 4.38 *Perform Analysis*

9. Furthermore, for checking prestressed concrete that has been designed beforehand, we must choose the guidelines we use and set the parameters first by selecting PSC > Design Parameter > Parameter from the Main Menu as shown in the figure below.

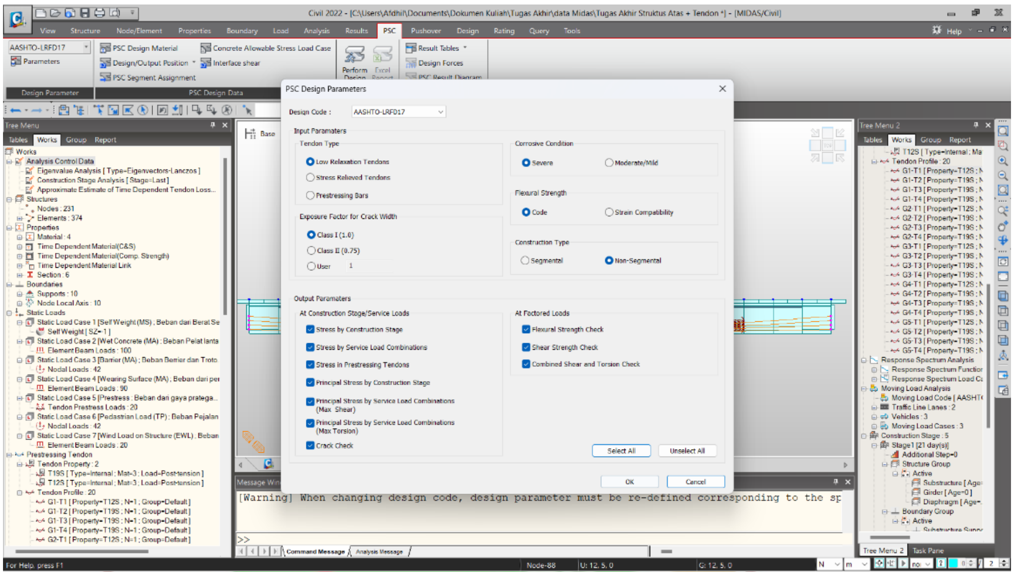

Figure 4.39 *Design Parameter*

10. Next, we need to define the material of the design that we calculated earlier, such as the quality of the concrete and the quality of the rebar steel used by selecting PSC > PSC Design Data > PSC Design Material from the Main Menu as shown in the figure below.

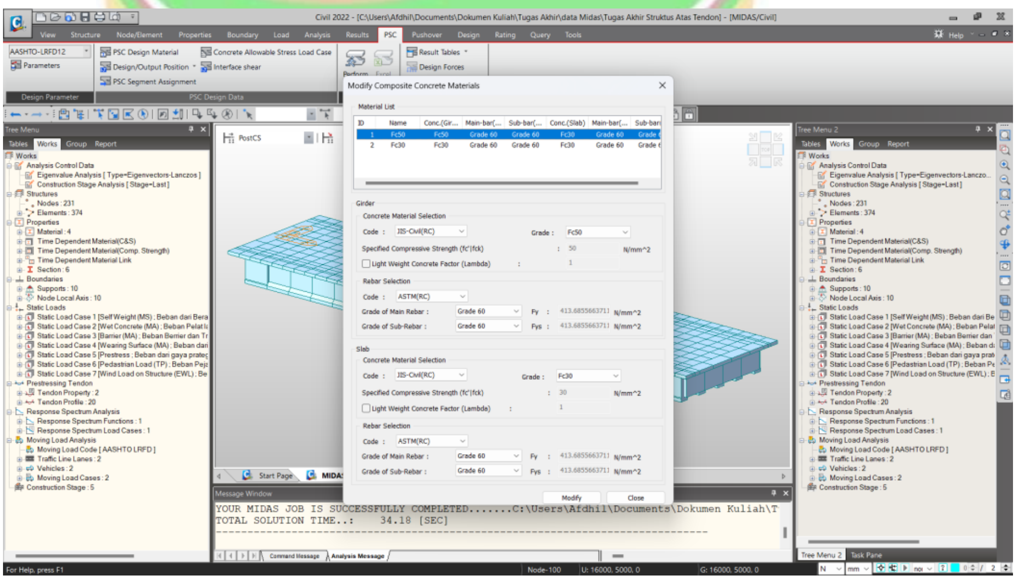

Figure 4.40 *PSC Design Material*

11. Then, Select the position of the prestressed concrete you want to check and export the calculation by selecting PSC > PSC Design Data > Design/Output Position from the Main Menu as shown in the figure below.

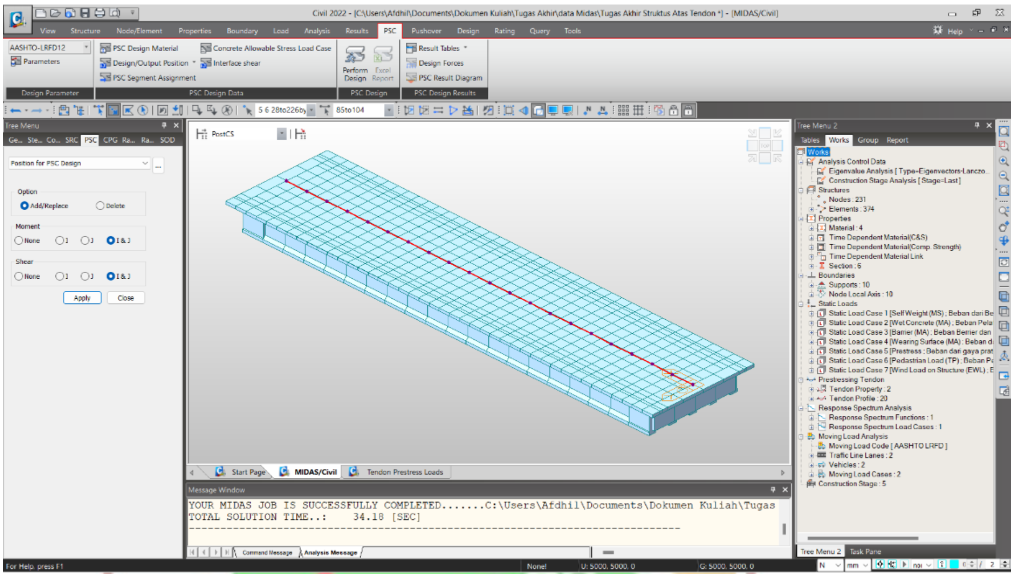

Figure 4.41 *Design/Output Position*

12. Then select Load Combination of the serving load used for checking the allowable stress on concrete by selecting PSC > PSC Design Data > Concrate Allowable Stress Load Case from the Main Menu as shown in the figure below.

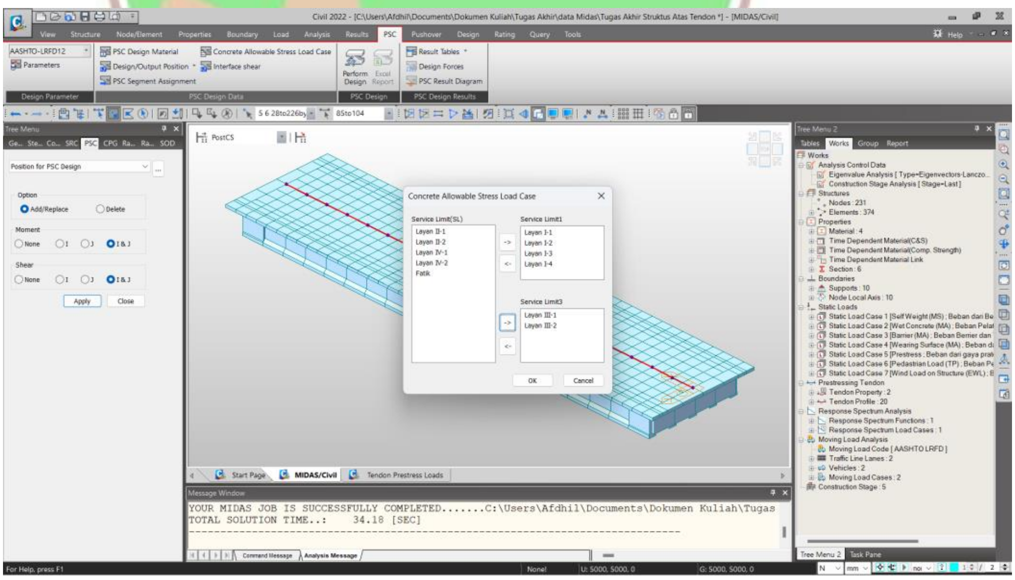

Figure 4.42 *Concrete Allowable Stress Load Case*

13. To start the inspection on the prestressed concrete design, we perform the design by selecting PSC > PSC Design > Perform Design from the Main Menu as shown in the figure below.

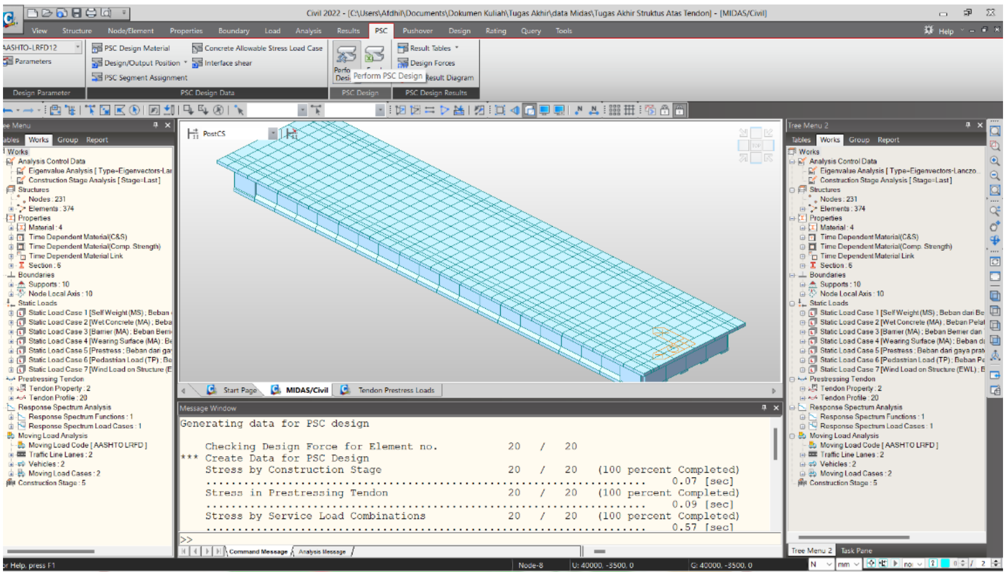

Figure 4.43 *Perform Design*

14. See the results of the Check on the prestressed concrete that has been carried out by selecting PSC > PSC Design Result > Result from the Main Menu as shown in the figure below.

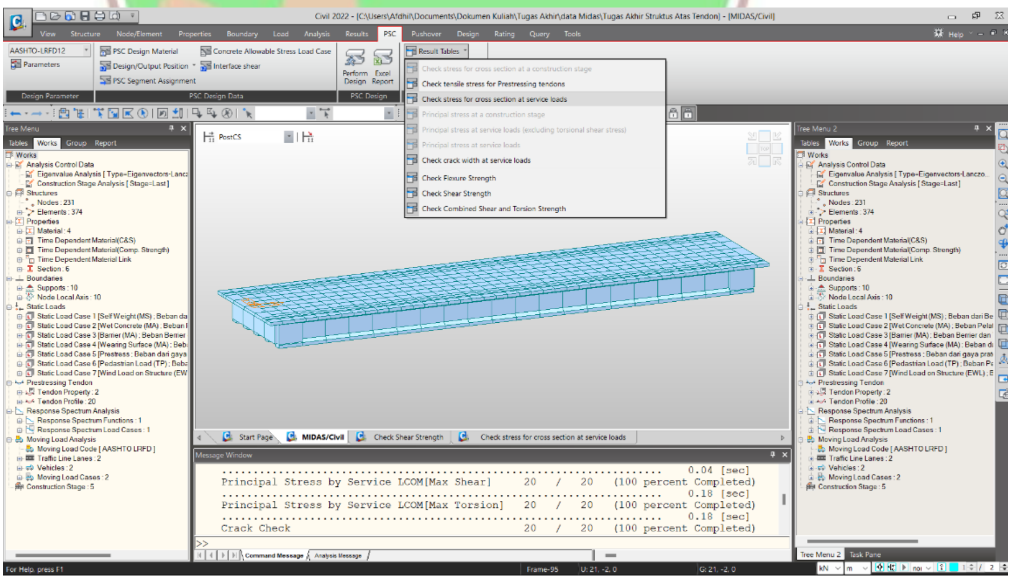

Figure 4.44 *Result Table*

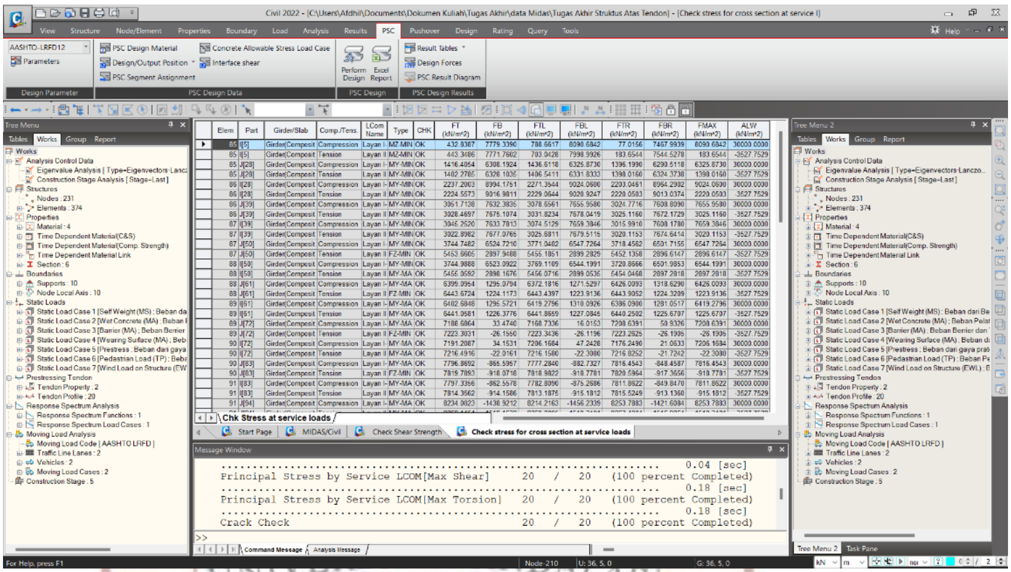

***Figure 4.45** Result Table of Checked Stress for Cross Section ar Service Load*

15. Export design check results by selecting PSC > PSC Design > Export Report from the Main Menu as shown in the figure below.

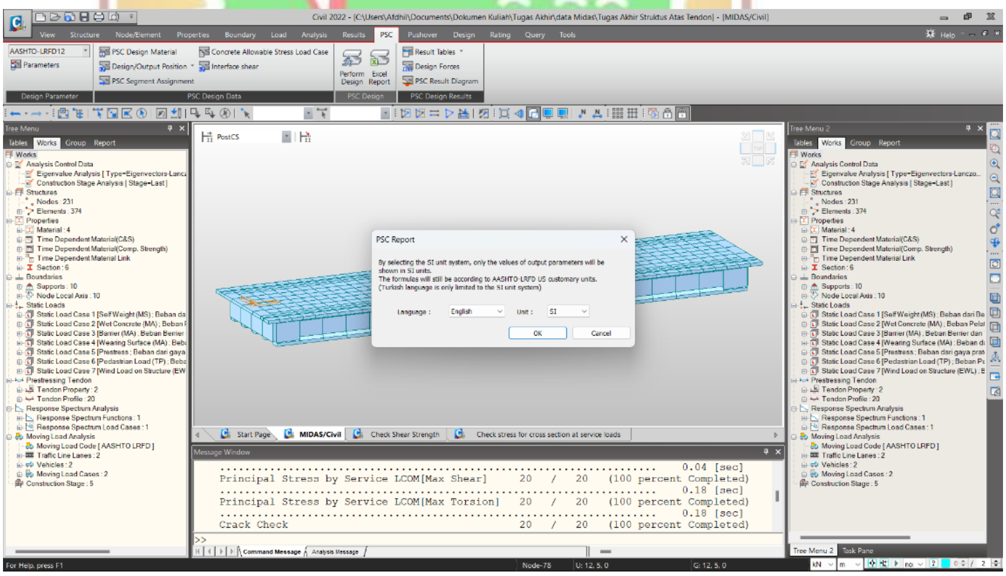

***Figure 4.46** Excel Report*

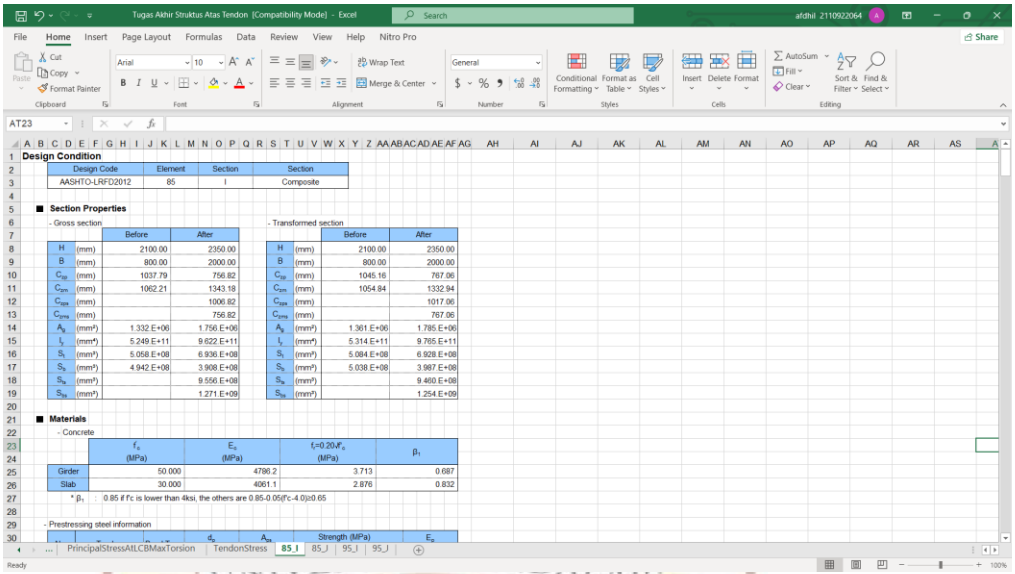

Figure 4.47 *Result of Excel Report*

Based on the Prestressed Concrete Check using Midas Civil that has been carried out in the middle of the span, the following results are obtained,

1. Final Effective Prestressed Force
   - Effective prestressed force   fpe   =   1061.564 kN
   - Tendon Stress Limit   fpe_max   =   0.8 fpy
     =   1339.20 kN
   - Control   fpe ≤ fpe_max (OK)

   Because the fpe value is smaller than fpe_max, The steel tendon is safe against the stress that occurs

2. Stress Check

   <u>*Allowable Stressed at Service Load*</u>

   - Tensile $\sigma t = -0.5\sqrt{f'cg}$
     $= -3.545$ MPa
   - Compression $\sigma c = 0.6\, f'cg$
     $= 30000$ MPa

   <u>*Stressed of Beam Girder at Service Load*</u>

   - Stressed at top fiber   ft   =   -3124.294 MPa ≤ σt (OK)
   - Stressed at Bottom fiber   fb   =   8981.759 MPa ≤ σc (OK)

Because the Stressed of the Beam Girder at the Service Load value Qualify allowable stress at the service load, the beam Girder can withstand the Stressed occurred

3. Flexure Strength Check

Flexure Resistance

- Maximum factored moment Mu = 2000 kN
- Nominal Flexure Resistance Mr = 1000 kN
- Control $Mr \geq Mu$ (OK)

Because the Mr value is greater than Mu, the beam girder can withstand the applied load.

Minimum Reinforcement check

- Maximum factored moment Mu = 2000 kN
- Cracking moment Mcr = kN
- Nominal Flexure Resistance Mr = 1000 kN
- Control $Mr \geq \min(1.33Mu, 1.2\ Mcr)$ (OK)

4. Shear Strength Check

- Maximum factored Shear Vu = 2000 kN
- Nominal Shear Resistance Vn = 1000 kN
- Control $Mr \geq Mu$ (OK)

Because the Vn value is greater than VU, the beam girder can withstand the applied load.

4.2.6. Reinforcement Calculation of Bridge Superstructure Component

The superstructure components for which the reinforcement is calculated are Girder Beams, Floor Plates, Diaphragms, and Deck slabs which will be attached to the attachment. The following is an example of the calculation of superstructure reinforcement from Girder Beams.

1. Reinforcement of Beam Girder (PCI-Girder)

Flexure Reinforcement of Beam Girder

Based on calculations of Midas Civil 2022, all prestressed concrete elements meet the minimum flexure reinforcement requirements. Therefore, for bending reinforcement used for reinforced concrete based on SNI 2847-2019 is for beams with tendons without adhesion, the minimum area of longitudinal thread reinforcement with adhesion (A_{smin}) must be:

$A_{smin} = 0.004\ A_{ct}$

where: Act = cross-sectional area of Girder beam

- Flexure reinforcement is needed for the Edge Section of PCI-Girder

Diameter of Rebar	:	Ds	=	=	13	mm
Area of Rebar	:	As	= [(1/4) π Ds^2]	=	132.732	mm^2
Cross-Sectional Area	:	Ag	= [Midas Civil Calculation]	=	1320300	mm^2
Reinforcement Area Required	:	As_req	= [0.4% Ag]	=	5281.200	mm^2
Number of Rebar Required	:	n	= [As_req / As]	=	39.788	
Number of Rebar Used	:		**40D13**			

- Flexure reinforcement is needed for the Middle Section of PCI-Girder

Diameter of Rebar	:	Ds	=	=	13	mm
Area of Rebar	:	As	= [(1/4) π Ds^2]	=	132.732	mm^2
Cross-Sectional Area	:	Ag	= [Midas Civil Calculation]	=	825550	mm^2
Reinforcement Area Required	:	As_req	= [0.4% Ag]	=	3302.200	mm^2
Number of Rebar Required	:	N	= [As_req / As]	=	24.879	
Number of Rebar Used	:		**26D13**			

Shear Reinforcement of Beam Girder (PCI-Girder)

Based on trial and error in Midas Civil 2022 to control the shear capacity of the girder beam, it is found that the shear reinforcement used is

Diameter of Rebar	:	Dv	=	=	13	mm
Number of Rebar	:	nv	=	=	2	
Area of Shear Reinforcement	:	Av	= [(1/4) * π * dv2 * nv]	=	265.465	mm^2
Specing of Field Reinforceme	:		**D13-200**			
Specing of Support Reinforce	:		**D13-100**			

2. Reinforcement of Floor Slab

General Data of Floor Slab

Effective Width of Floor Slabs	: b	= [Initial Data]	=	2000	mm
Thickness of Floor Slab	: ts	= [Initial Data]	=	250.000	mm
Concrete Grade	: fc'	= [Initial Data]	=	30.000	MPa
Yield Strength of Rainforcement Steel	: fy	= [Initial Data]	=	420	MPa
Concrete Cover	: cd	= [Input]	=	30	mm

Flexure Reinforcement of Floor Slab

Df	= [Input]	=	16	mm
ϕf	=	=	0.9	
Mu	= [Midas Civil Calculation]	=	138.01	kN.m
de	= [h - dc -0.5D]	=	212	mm
β_1	= [fc' > 30 MPa]	=	0.85	
ρ_b	= [β1* 0.85 * fc'/ fy * 600 / (600 + fy)]	=	0.0304	kN.m
Rnmax	= [0.75*ρb*fy*(1–½*0.75*ρb*fy/(0.85*fc')]	=	7.7695	kN/m^2
Mn	= [Mu / ϕ]	=	153.339	mm^2
Rn	= [Mn * 10^6 / (b * de^2)]	=	1.706	kN/m^2
	Rn < Rnmax	=	OK!	
ρ	= [0.85*fc'/fy*(1-√[1 – 2 * Rn/(0.85*fc'))]	=	0.0042	
ρ_{min}	= [1.4 / fy]	=	0.0033	
ρ	= [min (ρ , ρ min)]	=	0.0042	
As	= [ρ * b * de]	=	1784	mm^2
Smax	= [(1/4) * π * D^2 * b / As]	=	225	mm
S	=	=	100	mm
Longitudinal Flexure Reinforcement Used		=	**D16 - 100**	

Transverse Reinforcement of Floor Slab

Dv	= [Input]	=	13	mm
Pt	= [Min (110/√S, 67%]	=	67	%
As_req	= [(As_req * Pt)]	=	1195.24	mm^2
Smax	= [(b * (1/4) * π * D^2)/ As_req]	=	222.101	mm
S		=	100	mm
Specing of Transverse Reinforcement Used		=	**D13 - 100**	

The following is a recapitulation of the reinforcement used in the superstructure of the bridge after the calculation,

Table 4.2 *Beam Girder Reinforcement*

Reinforcement Type	Specification
Flexure reinforcement of edge PCI-Girder	40D13
Flexure reinforcement of middle PCI-Girder	26D13
Field shear reinforcement	D13 - 200
Support shear reinforcement	D13 - 100

Table 4.3 *Floor Slab Reinforcement*

Reinforcement Type	Specification
Longitudinal flexure reinforcement	D16 - 100
Transverse flexure reinforcement	D13 - 100

Table 4.4 *Diaphragm Reinforcement*

Reinforcement Type	Specification
Flexure reinforcement	D13 - 200
Shear reinforcement	D10 - 200

Table 4.5 *Deck Slab Reinforcement*

Reinforcement Type	Specification
Longitudinal flexure reinforcement	D10 - 200
Transverse flexure reinforcement	D10 - 300

4.2.7. Other Detailing of Bridge Superstructure

1. Elastomer Bearing Pad

   Elastomer-bearing pads are an important element in bridge construction that absorb and distribute loads and movements between the bridge structure and its supports such as abutments. Bearing pads help maintain the bridge's stability and ensure that the force and movement received by the bridge can be handled effectively while reducing damage to the structure of the bridge itself.

   based on the elastomeric bearing data mentioned earlier with dimensions of 600 cm x 600 cm x 97 cm as shown in the figure below.

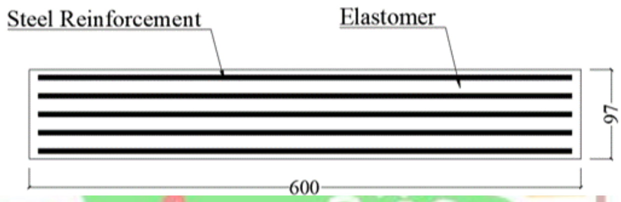

Figure 4.48 Elastomer Bearing Pad

   The elastomer bearing pad used must withstand the reaction of the bridge superstructure so that there is no damage to the pad when receiving the load. The check was carried out that there was an allowable load that could be carried by the elastomer bearing pad and the reaction of the bridge superstructure as shown in the data below.

   - Allowable Compressive Strength of Elastomer Fn = 2930.000 kN
   - Compressive Strength of Superstructure Reaction Fz = 2212.008 kN
   - Control $Fz \leq Fn$ (OK)

   Based on the above check, the elastomer can withstand the load generated by the reaction of the bridge superstructure

2. Connectors Between Segments (Pin Connector)

   In this research, the bridge designed is a segmental prestressed concrete bridge that requires a connection to connect between the segments. The type of connection used is Pin Connector with details as shown in the figure below.

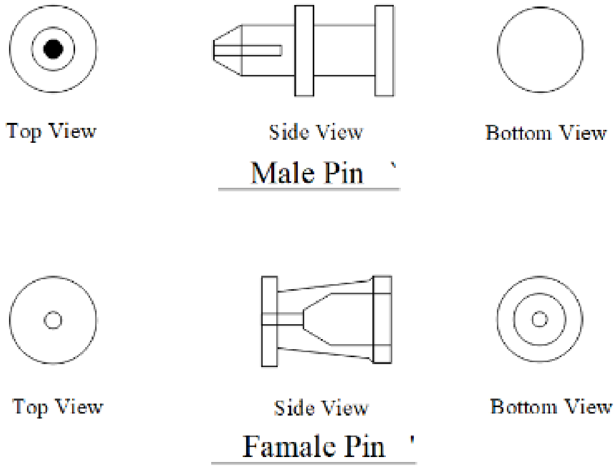

Figure 4.49 *Pin Connector*

4.3. DESIGN OF BRIDGE SUBSTRUCTURE AND FOUNDATION

4.3.1. Preliminary Design of Bridge Substructure and Foundation

The bridge substructure consists of several parts such as the breast wall, back wall, wing wall, and approach slab. The breast wall is the bridge's substructure at the start and end of the bridge. This bridge's substructure supports the superstructure and as a transition from oprit to the bridge floor. The piles from the oprit and the road body are held by the back wall, while the side piles are held by the wing wall. Meanwhile, the approach slab is useful for connecting roads and bridges so that there is no too noticeable change in height on both.

In the planning of the prestressed concrete bridge, the height of the planned abutment is 9 meters. Based on *Panduan Teknik pelaksanaan jembatan (2021)*, abutments with a height ranging from 6-12 meters generally use inverted T-type abutments. So the substructure that will be designed has dimensions like the one in the image below.

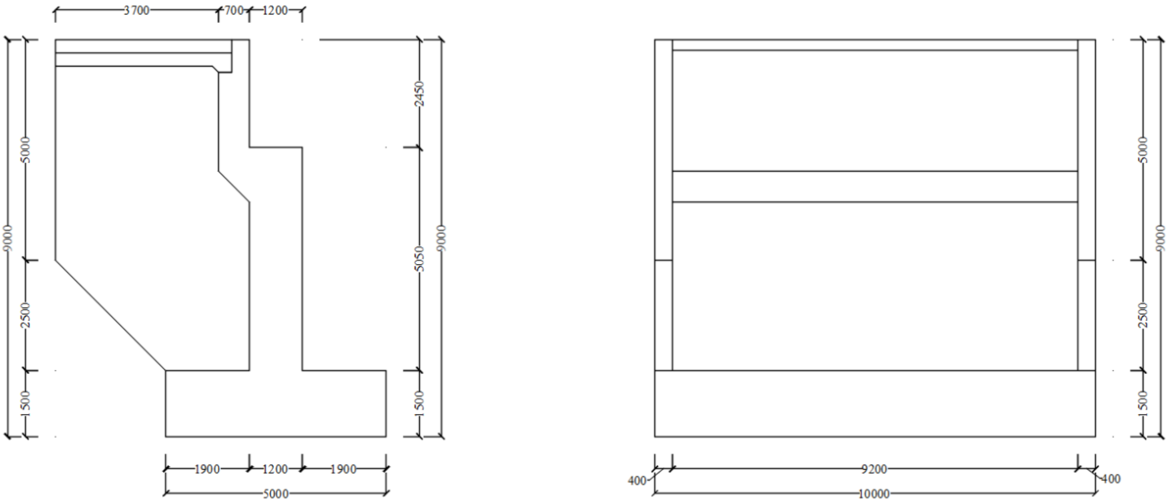

Figure 4.50 *Dimension of Bridge Substructure*

As previously explained, According to FHWA NHI-05-042 Design and Construction of Driven Pile Foundation, page 7-4, the type of foundation that matches the soil conditions is the pile foundation with a depth of 15 meters and a pile diameter of 0.8 meters and has 10 piles shown in the figure below.

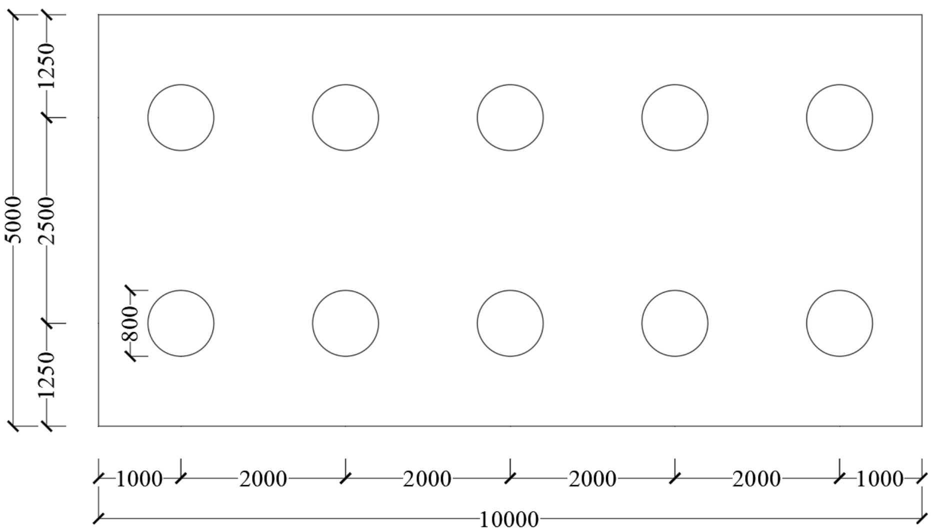

Figure 4.51 *Dimension of Pile*

4.3.2. Structural Analysis of Substructure Using Midas Civil 2022

The stages that can be carried out in the analysis of the substructure and foundation using Midas Civil 2022 include the following.

1. Open Midas Civil 2023 that has been installed on your PC so that the initial display appears as shown below, then select New Project to create a new worksheet.

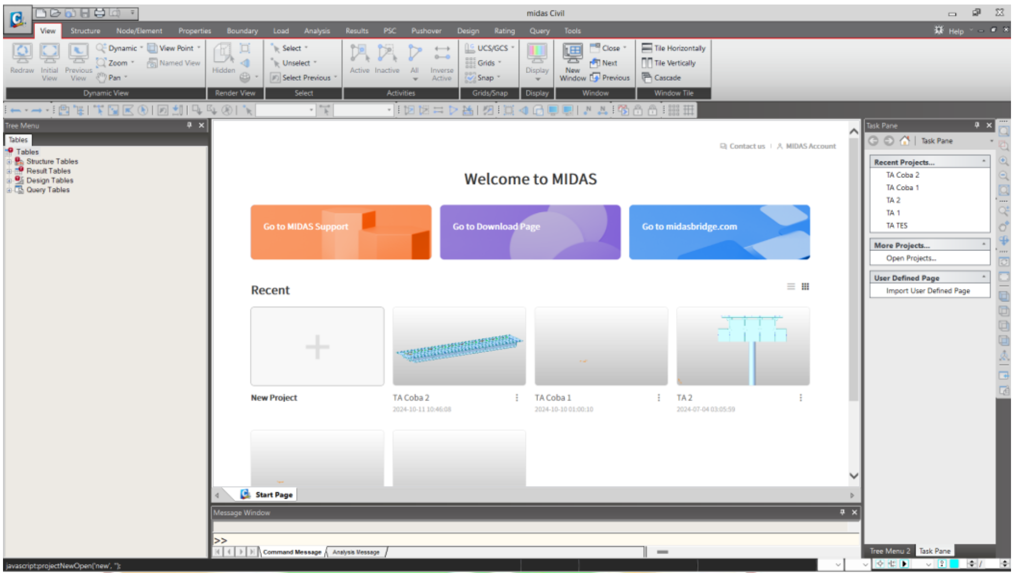

Figure 4.52 *Initial View of Midas Civil 2022*

2. Define the material used in modeling the bridge's substructure to be analyzed, which has been mentioned in the previous substructure and foundation data, such as fc'30 concrete by selecting Properties > Material > Material from the Main Menu as shown in the figure below.

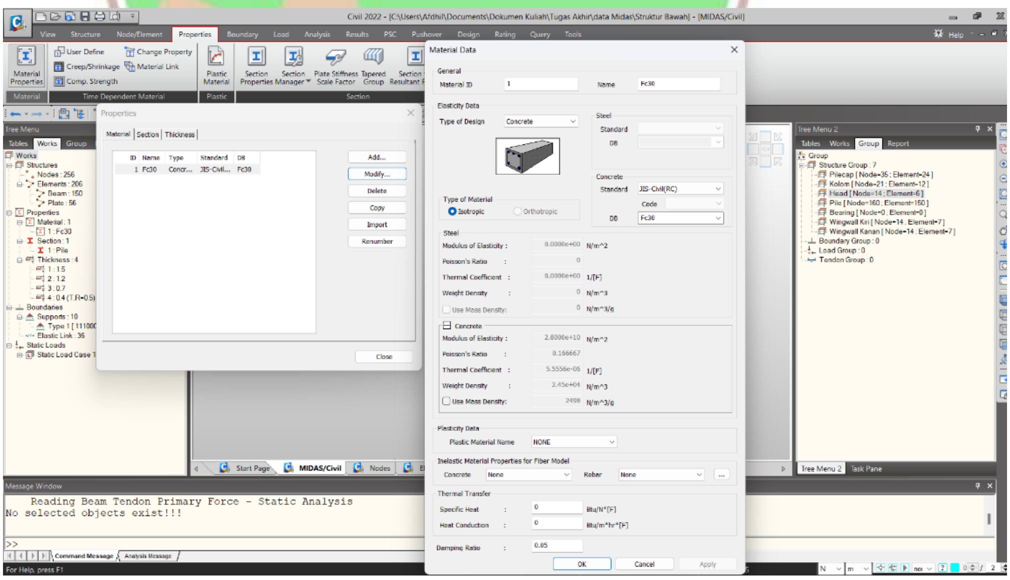

Figure 4.53 *Material Properties*

3. Next, Define Section Properties for the pile used by selecting Properties > Section > Section Properties from the Main Menu as shown in the figure below.

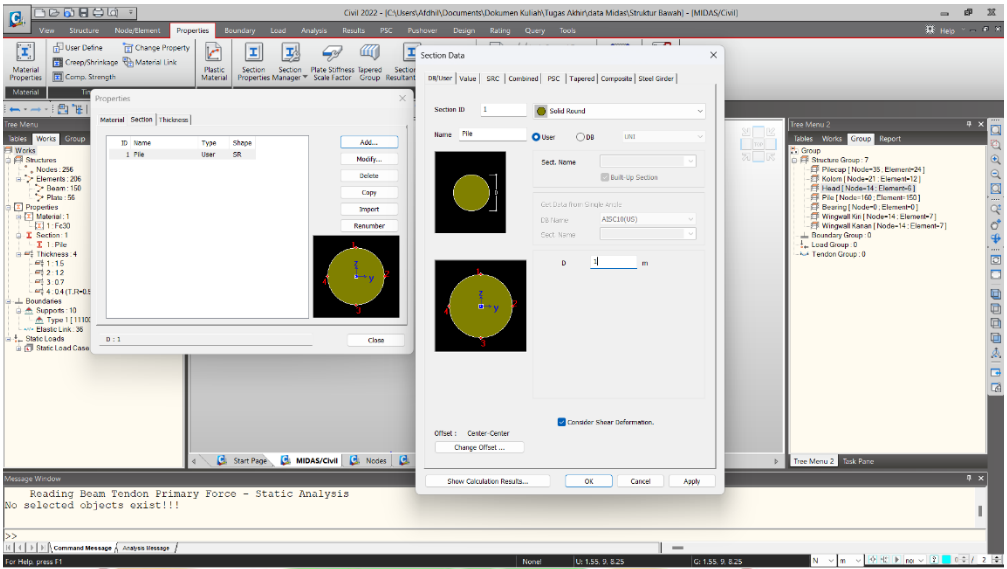

Figure 4.54 *Section Properties*

4. Then also define the Thickness of the Pilecap, Breastwall, Backwall, Approach Slab, and Wingwall used by selecting Properties > Section > Thickness from the Main Menu as shown in the figure below.

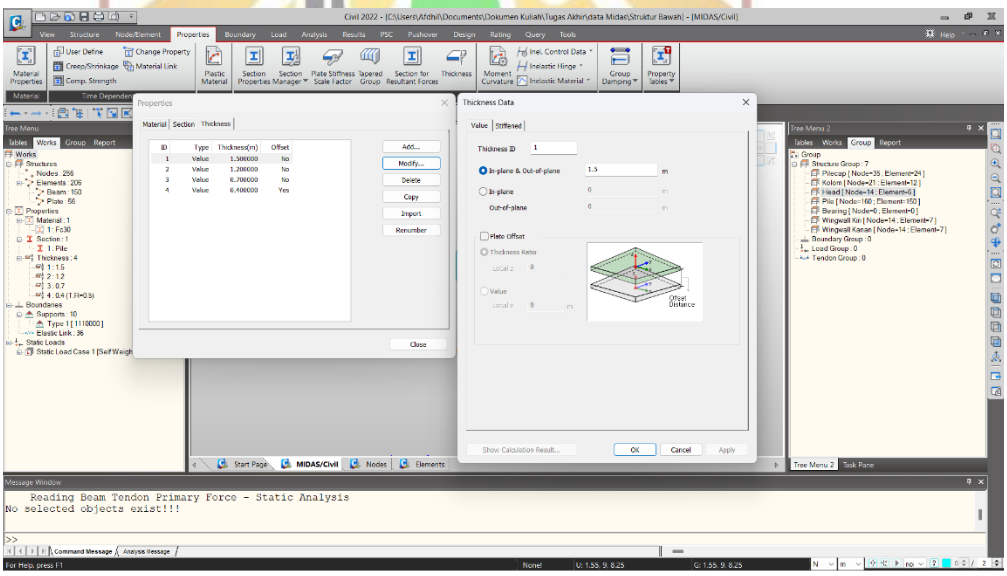

Figure 4.55 *Thickness*

5. Create a node for each element of the substructure and foundation that is useful for the modeling by selecting Node/Elements > Nodes from the Main Menu. In the creation of this node, it can be done by copying, rotating points, etc. according to the coordinates of the node to be created as shown in the figure below

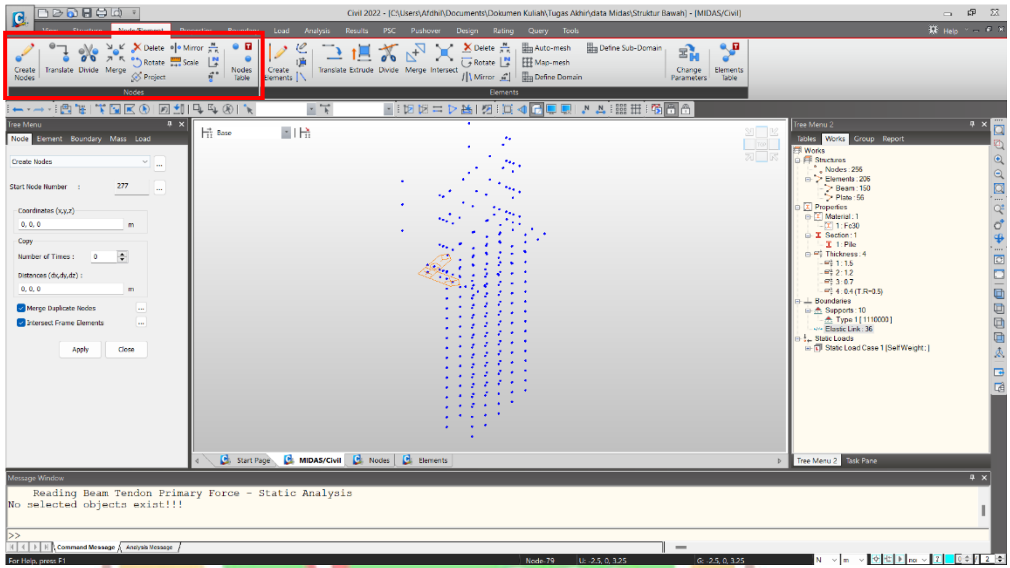

Figure 4.56 *Create Nodes*

6. Then create an element from each substructure and foundation element of the previously created node by selecting Node/Elements > Element from the Main Menu as shown in the figure below.

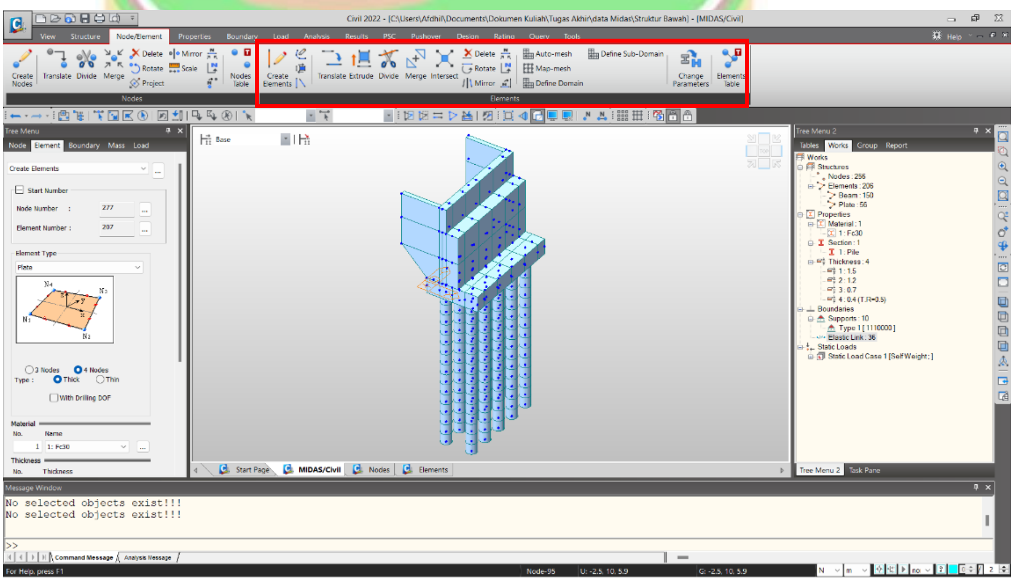

Figure 4.57 *Create Elements*

7. Connect each element of the structure whose nodes are not bound to each other by selecting Boundary> Link > Elastic Link from the Main Menu and for Elastic Link Data select Rigid as shown in the figure below.

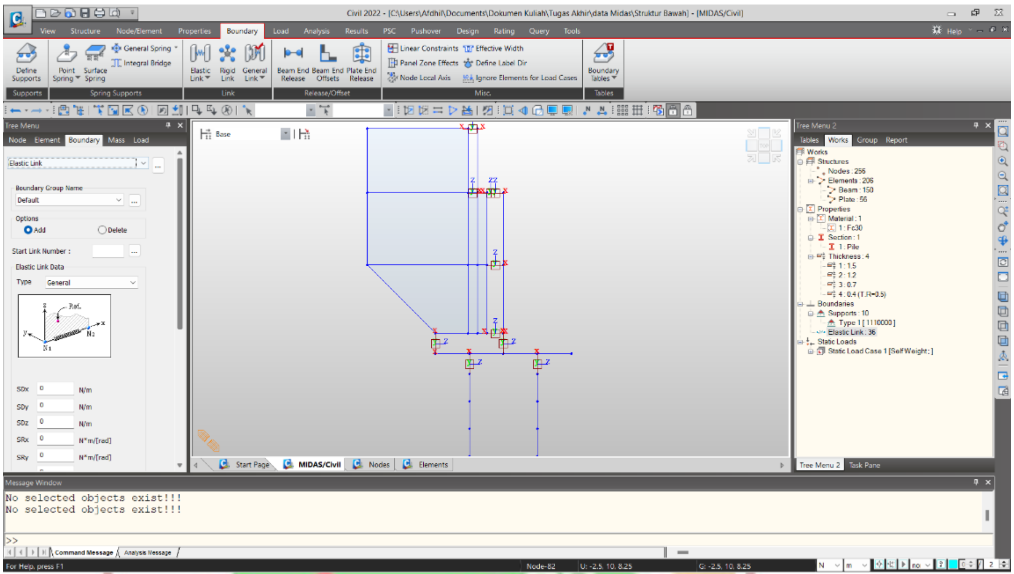

Figure 4.58 *Elastic Link (Rigid)*

8. Then define the support on the pile foundation by selecting Boundary > Support > Define Support from the Main Menu as shown in the figure below.

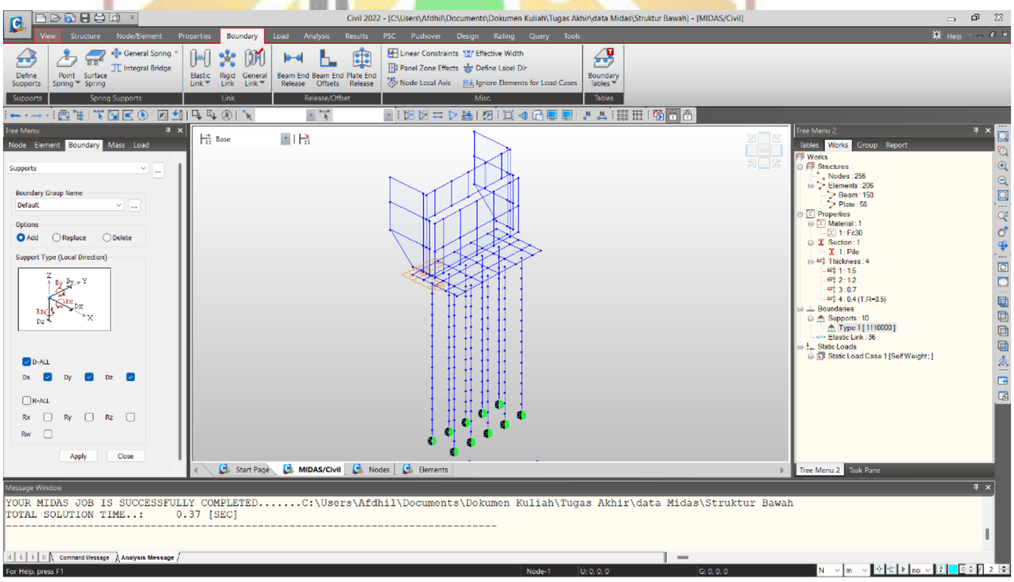

Figure 4.59 *Define Support*

9. Next, check the modeling of the bridge substructure and foundation that has been carried out by performing an Analysis and see the Displacement Contour that occurs, if the results of the Displacement Contour produced are like the figure below, then we can proceed to the loading stage.

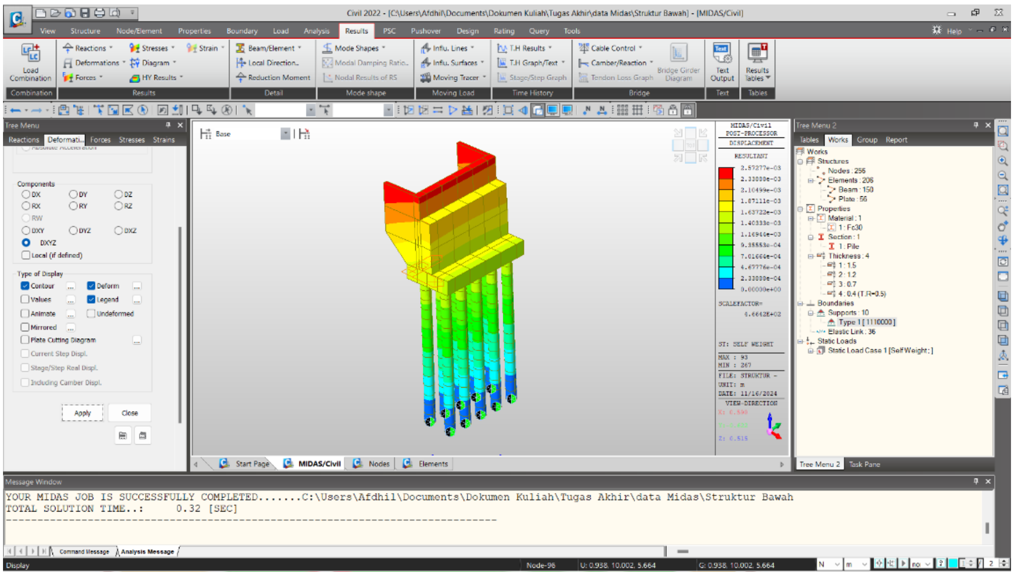

***Figure 4.60** Checking Substructure Modeling by Viewing Displacement Contour*

10. Create a Load Case for each load to be inserted by selecting Load > Load Type > Static Load > Create Load Cases > Static Load Cases from the Main Menu as shown in the figure below.

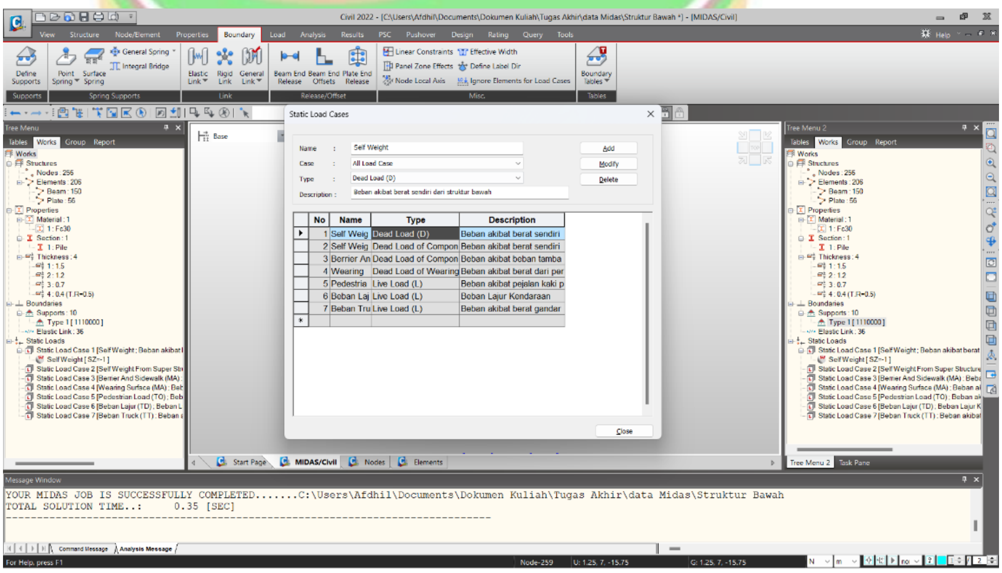

***Figure 4.61** Load Case*

11. Next, input load from the superstructure pedestal that has been generated from the superstructure analysis previously performed for each load from the superstructure by selecting Load > Load Type > Static Load > Structure Load/Masses > Nodal Loads from the Main Menu as shown in the figure below, with the following data.

- Self-weight of the Superstructure F_{SW} = 721.560 kN
- Barrier and Sidewalk Load F_{MA1} = 162.978 kN
- Wearing Surface load F_{MA} = 38.733 kN
- Pedestrian Load F_{TP} = 48.854 kN
- Line Load F_{TD} = 337.704 kN
- Truck Load F_{TT} = 323.491 kN

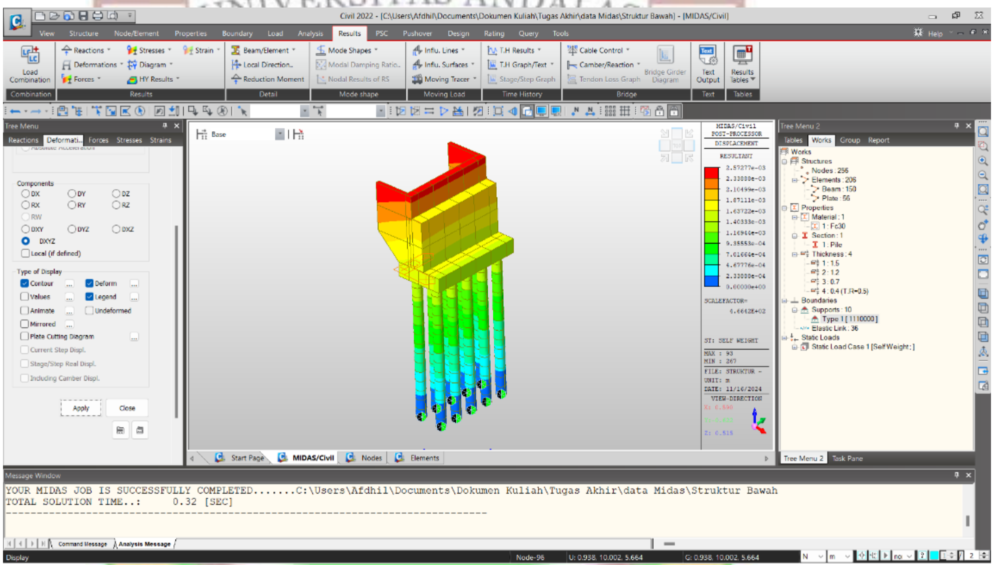

***Figure 4.62** Node Load of Loads from the Superstructure*

12. Next, input the load due to active ground pressure on the Backwall, Breast wall, and Wingwall by selecting Load > Load Type > Static Load > Pressure Load > Pressure Load from the Main Menu as shown in the figure below with the following values.

- Specific Gravity of Soil γ = 18 kN/m^3
- Angle of Internal Friction φ = 30°
- Cohesion of Soil K_a = 0.33 kN
- Active Ground Pressure for Depth 0 m P_{TA1} = 0.00 kN/m^2
- Active Ground Pressure for Depth 2.4 m P_{TA2} = 7.20 kN/m^2
- Active Ground Pressure for Depth 5.5 m P_{TA3} = 16.5 kN/m^2
- Active Ground Pressure for Depth 7.5 m P_{TA4} = 22.5 kN/m^2

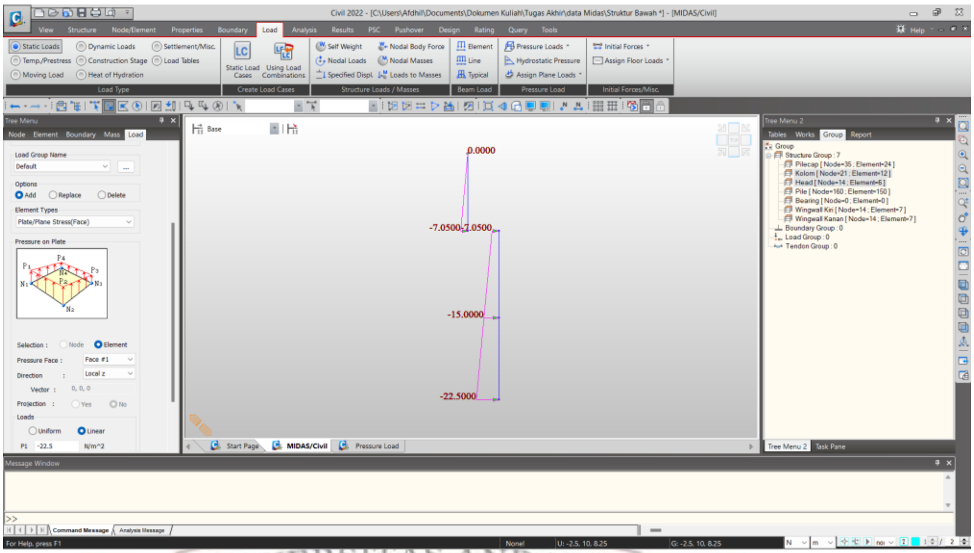

Figure 4.63 *Active Ground Pressure on Back Wall and Breast Wall*

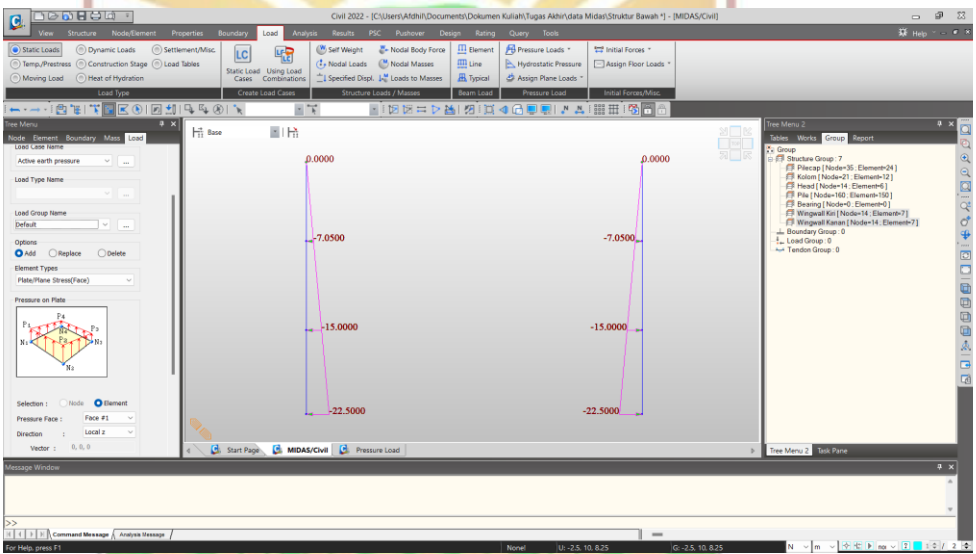

Figure 4.64 *Active Ground Pressure on Wingwall*

13. The next step, remove the foundation from the pile that we have made previously and input the Boundery from the pile with the NSPT data from the soil according to the data that has been presented previously by selecting Boundery > Spring Support > Integral Bridge from the Main Menu then on Soil Spring Type select Pile Spring and enter soil data according to the available data as shown in the figure below.

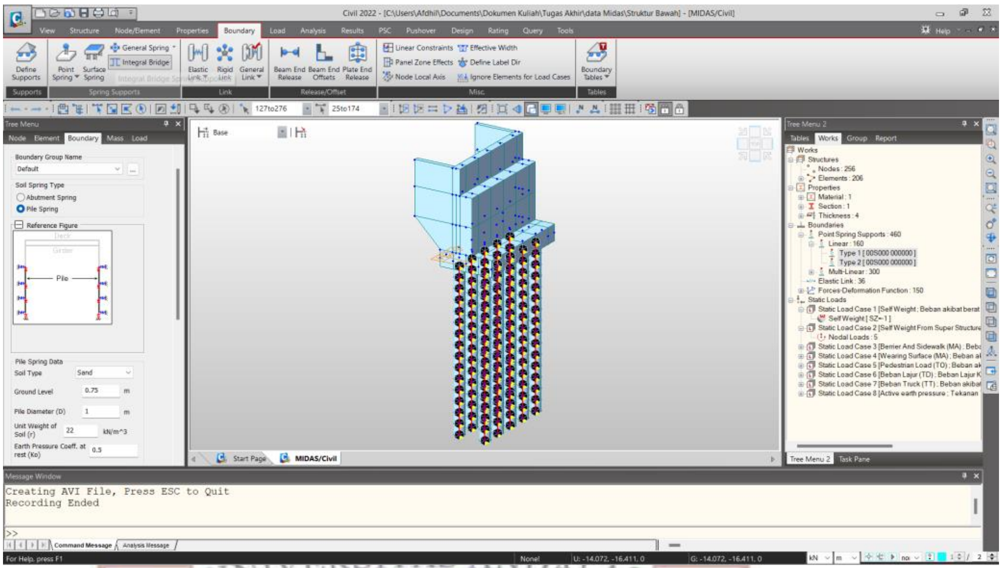

Figure 4.65 *Integral Bridge (Pile Spring)*

14. Input the Spectral Response earthquake data such as the earthquake data that we have entered into the Spectral Response earthquake data on the superstructure and also make a Load Case from the Spectral Response by selecting Load > Load Type > Dynamic Loads > Response Spectrum Data from the Main Menu as shown in the figure below.

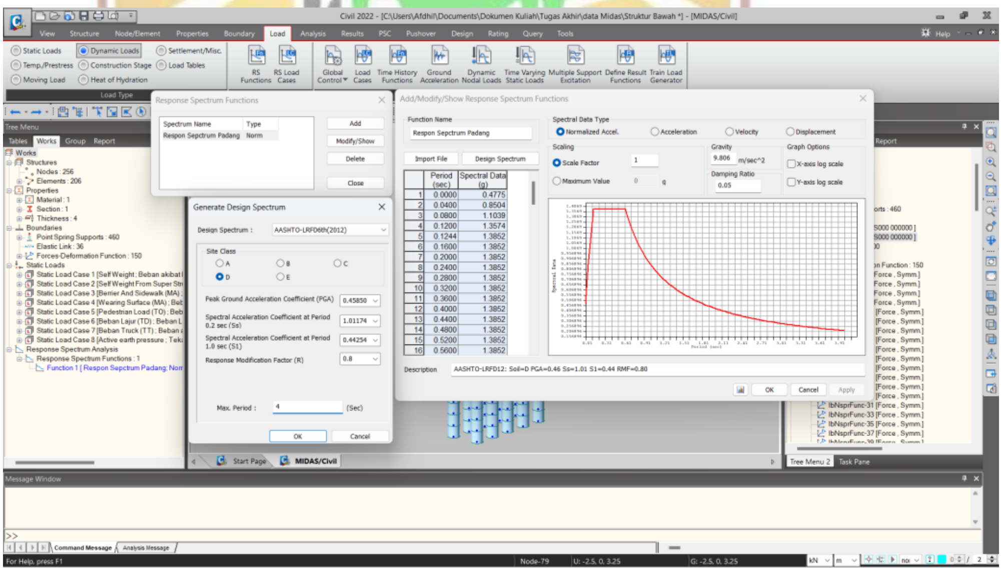

Figure 4.66 *Response Spectrum of Padang*

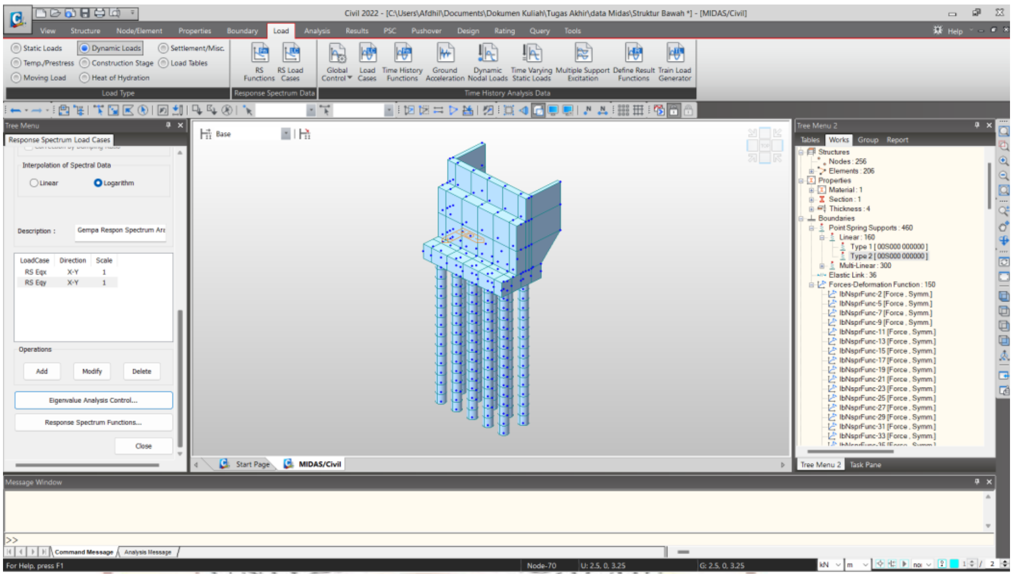

Figure 4.67 *RS Load Cases*

15. Then make a combination of loads used following SNI 1725:2016 by selecting Result > Combination > Load Combination from the Main Menu as shown in the figure below.

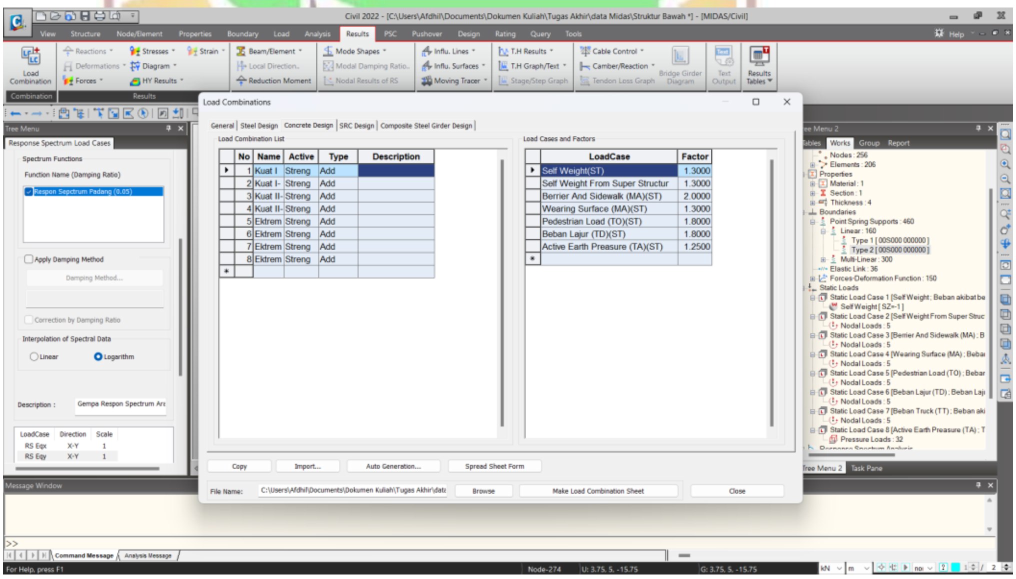

Figure 4.68 *Load Combination*

16. Next, analyze the bridge structure that has been modeled earlier by selecting Analysis > Perform > Perform Analysis from the Main Menu or you can press the F5 key, then all the results of the analysis can be seen in the Result menu as shown in the figure below

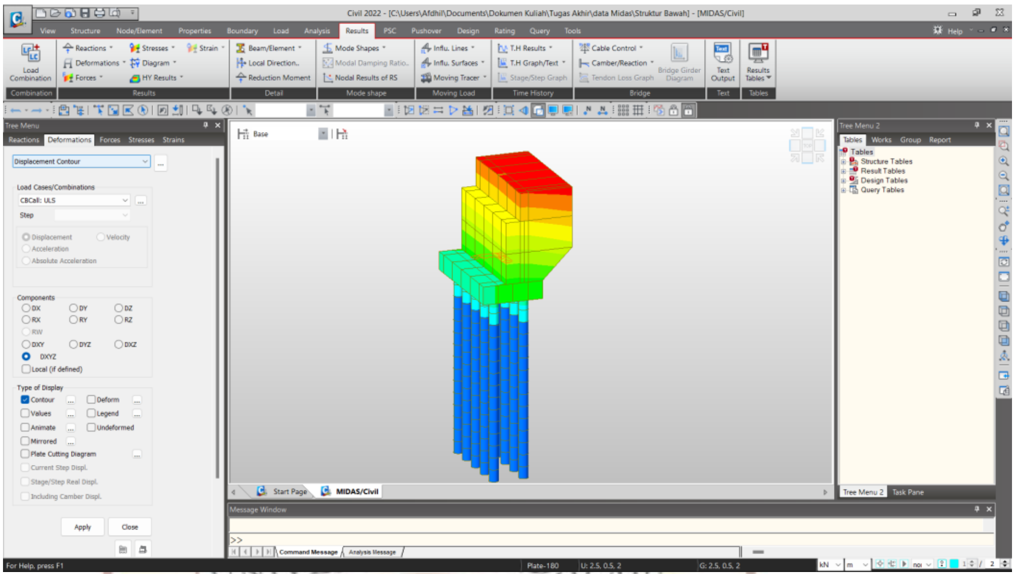

Figure 4.69 *Perform Analysis*

4.3.3. Stability of Bridge Abutment

To ensure that the abutment can work properly and safely, stability calculations must be carried out by paying attention to several aspects. Some of the factors that need to be calculated and analyzed include:

1. Abutment Stability Against Tipping (Rolling)

   The stability of the abutment against the tipping is a condition in which the abutment can prevent the occurrence of reversal (Rolling) or rotation caused by the moment acting on the structure. This reversal can occur when the load received by the abutment produces a moment greater than the abutment's ability to hold it. To keep the abutment from tipping over, it is important to ensure that the moment acting on the abutment is less than the holding moment provided by the structure and the soil that supports it. The following is the calculation of the stability of the Abutment Rolling,

Vertical Moment	: Mv	= [Midas Civil Calculation]	=	699.099	kN.m
Horizontal Moment	: Mh	= [Midas Civil Calculation]	=	332.053	kN.m
Factor of Safety	: SoF		=	2	
Factor of Safety For Tipping	: Soft	= [Mv/Mh]	=	2.105	
Control		= [SoFt > SoF]	=	OK!	

2. Abutment Stability Against Shearing

The abutment must be stable against horizontal forces so that it does not shift. The calculation for friction stability can be done by comparing the shear force received with the shear force that can be resisted by friction between the abutment and the foundation.

Angle of Internal Friction	: ϕ	=		=	30	°
Cohesion of Soil	: C	=		=	1	kN/m2
Area of Abutment Base	: A	=	[P . L]	=	50	m2
Vertical Force	: V	=	[Midas Civil Calculation]	=	1595.59	kN
Horizontal Force	: H	=	[Midas Civil Calculation]	=	325.934	kN
Factor of Safety	: SoF			=	1.5	
Factor of Safety For Shear	: Sofx	=	[((C * A) + (V * tan ϕ)) / I	=	2.980	
Control		=	[SoFx > SoF]	=	OK!	

4.3.4. Bearing Capacity of Pile Foundation

Foundation Bearing Capacity is the maximum capacity that the soil or foundation structure can bear without causing failure or excessive subsidence. The bearing capacity of the foundation is very important in the design of buildings or other structures because a foundation that does not have sufficient bearing capacity can result in damage to existing structures. The bearing capacity of a foundation can be calculated based on a variety of factors, including soil type, foundation depth, and the physical and mechanical properties of the soil on site.

N-SPT for Depth 0 - 6 m	: N1	= [Initial Data]	=	10	
N-SPT for Depth 6 - 15 m	: N2	= [Initial Data]	=	50	
Soil Specific Gravity for Depth 0 - 6 m	: γ1	= [Initial Data]	=	18	kN/m^3
Soil Specific Gravity for Depth 6 - 15 m	: γ2	= [Initial Data]	=	22	kN/m^3
Safety of Factor	: SoF	= [Initial Data]	=	2.5	

Length of Pile	: H	= [Preliminary Design]	=	15 m
Pile Length at Depth 0 - 6 m	: H1	= [Preliminary Design]	=	6 m
Pile Length at Depth 6 - 15 m	: H2	= [Preliminary Design]	=	9 m
Diameter of Pile	: D	= [Preliminary Design]	=	0.8 m
Lateral Surface Area for Depth 0 - 6 m	: AS1	= [π * D * H1]	=	15.080 mm^2
Lateral Surface Area for Depth 6 - 15 m	: AS2	= [π * D * H2]	=	22.619 mm^2
Pile Area Tip	: At	= [(1/4) * π * D2]	=	0.503 mm^2

4.3.5. Reinforcement Calculation of Bridge Substructure and Foundation

The substructure and foundation components for which the reinforcement is calculated are Breast wall, Back wall, Wing wall, approach slab, Pile cap, and Pile which will be attached to the attachment. The following is an example of the calculation of superstructure reinforcement from Pile Cap.

1. Reinforcement of Breast Wall

General Data of Breast Wall

Height of Breastwall	: h	= [Initial Data]	=	1200 mm
Longitudinal Width of Breastwall	: bx	= [Initial Data]	=	10000 mm
Transversal Width of Breastwall	: by	= [Initial Data]	=	5050 mm
Concrete Grade	: fc'	= [Initial Data]	=	30 MPa
Yield Strength of Rainforcement Steel	: fy	= [Initial Data]	=	420 MPa
Concrete Cover	: dc	= [Input]	=	50 mm

Axial – Flexure Reinforcement of Breast Wall

Db	= [Input]	=	25 mm
Mux	= [Midas Civil Calculation]	=	699.099 kN.m
Muy	= [Midas Civil Calculation]	=	332.053 kN.m
Pu	= [Midas Civil Calculation]	=	1595.59 kN
S	= [Input]	=	150 mm

n	= [bx / s]	=	67	
As	= [n * (1/4) * π *Db^2]	=	65777.10	mm^2
Ag	= [bx * by]	=	12000000	mm^2
ρ	= [As / Ag]	=	0.548	%
ρ_{min}		=	0.500	%
	$\rho_{min} > \rho$	=	OK	
Axial-Flexure Reinforcement Used		=	**D 25 - 150**	

With the help of SpColumn software, you can get the axial-flexural interaction diagram of the Breast wall as shown in the image below,

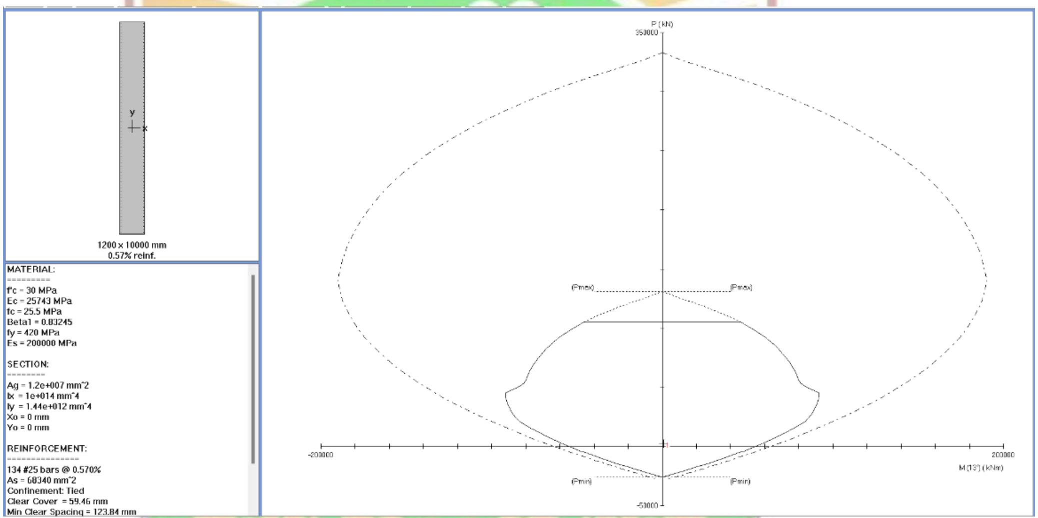

Figure 4.70 *Axial - Flexural Interaction Diagram of the Breast Wall*

The combination of Pu and Mu loads in the axial-flexural interaction diagram of the Breast wall indicates that the Breast wall section can carry the loads that occur. The interaction diagram above is an interaction diagram of the abutment cross section using the main reinforcement is D25 - 150

Transverse Reinforcement of Breast Wall

D	= [Input]	=	16	mm
λ	=	=	1	
β	=	=	2	
ϕv	= [SNI 2847-2019]	=	0.75	
Vu	= [Midas Civil Calculation]	=	316.681	kN.m
b'	=	=	1000	mm
de	= [h - dc -0.5D]	=	1142	mm
Vc	= [0.083 * β * √(f'c Mpa) *b *de]	=	10383.29	kN
	= [0.5 ϕv Vc]	=	3893.732	
Vu < 0.5 ϕv Vc				
Shear Reinforcement is Required				
Av_min	= [(0.083*λ*√(f'c Mpa)*b*b') / fy]	=	10824.04	mm2
S		=	150	mm
Av_use	= [(1/4) * π * D^2 * b / S]	=	13404.13	mm2
	Av_use < Av_min	=	OK!	
Shear Reinforcement Used		=	**D16 - 150**	

Transverse Reinforcement of Breast Wall

D	= [Input]	=	16	mm
λ	=	=	1	
β	=	=	2	
ϕv	= [SNI 2847-2019]	=	0.75	
Vu	= [Midas Civil Calculation]	=	316.681	kN.m
b'	=	=	1000	mm
de	= [h - dc -0.5D]	=	1142	mm
Vc	= [0.083 * β * √(f'c Mpa) *b *de]	=	5191.643	mm2
	= [0.5 * ϕv * Vc]	=	1946.866	

$Vu < 0.5 * \phi v * Vc$

Shear Reinforcement is Required

Sy		=	600	mm
Vs	= [(Vu / ϕv) - Vc]	=	-4769.4	kN
Av_1	= [(Vs * b) / (fy * de)]	=	-99437.1	mm2
Av_min	= [(0.083*λ*√(f'c Mpa)*b*b') / fy]	=	10824.04	mm2
Av	= [Max (Av_1, Av_min)]	=	10824.04	mm2
Sx_max	= [(b*s*(1/4)*π*D^2) / (Av*Sy)]	=	309.5916	mm
Sx		=	300	mm
Shear Reinforcement Used		=	**D16 - 300/600**	

2. Reinforcement of Pile Cap

General Data of Pile Cap

Height of Backwall	: h	= [Initial Data]	=	700	mm
Longitudinal Width of Backwall	: bx	= [Initial Data]	=	10000	mm
Transversal Width of Backwall	: by	= [Initial Data]	=	2400	mm
Concrete Grade	: fc'	= [Initial Data]	=	30	MPa
Yield Strength of Rainforcement Steel (I	: fy	= [Initial Data]	=	420	MPa
Concrete Cover	: dc	= [Input]	=	50	mm

Longitudinal Flexure of Pile Cap

D	= [Input]	=	25	mm
ϕ_f	= [SNI 2847-2019]	=	0.9	
Mu	= [Midas Civil Calculation]	=	332.427	kN.m
b'	=	=	1000	mm
de	= [h - dc -0.5D]	=	1437.5	mm
β_1	= [fc' > 30 MPa]	=	0.85	
ρ_b	= [β1* 0.85 * fc'/ fy * 600 / (600 + fy)]	=	0.030357	

Rnmax	= [0.75*ρb*fy*(1–½*0.75*ρb*fy/(0.85*fc')]	=	7.770	kN/m^2
Mn	= [Mu / ϕ]	=	369.36	kN.m
Rn	= [Mn * 10^6 / (b' * de^2)]	=	0.179	kN/m^2
	Rn < Rnmax	=	OK!	
ρ	= [0.85*fc'/fy*(1-√[1 – 2 * Rn/(0.85*fc'))]	=	0.0004	
ρ_{min}	= [0.5 / fy]	=	0.0012	
ρ	= [min (ρ , ρ min)]	=	0.0012	
As	= [ρ * b' * de]	=	1711	mm^2
Smax	= [(1/4) * π * D^2 * b' / As]	=	287	mm
S	=	=	150	mm
Longitudinal Flexure Reinforcement Used		=	D25 - 150	

Transverse Reinforcement of Pile Cap

D	= [Input]	=	19	mm
As'	= [50% ∗ As]	=	856	mm^2
S'max	= [(1/4) * π * D^2 * b / As]	=	331	mm
S'	=	=	150	mm
Longitudinal Flexure Reinforcement Used		=	**D19 - 150**	

Shear Reinforcement of Pile Cap

Dv	= [Input]	=	16	mm
λ		=	1	
ϕv	= [SNI 2847-2019]	=	0.75	
Vu	= [Midas Civil Calculation]	=	110.527	kN
de	= [h - dc - 0.5Dv]	=	1442	mm
b''	=	=	1000	mm
Vc	= [(1/6) √(f'c Mpa) b de]	=	13163.6	kN
	= [0.5 ϕv Vc]	=	4936.35	kN

Vu < 0.5 ϕv Vc

Shear Reinforcement is Required

Sy	=	=	600	mm
Vs	= [(Vu / ϕv) - Vc]	=	-13016.2	kN
Av_1	= [(Vs * b) / (fy * de)]	=	-214917	mm^2
Av_min	= [(0.083*λ*√(f'c Mpa)*b*b') / fy]	=	10824.04	mm^2
Av	= [Max (Av_1, Av_min)]	=	10824.04	mm^2
Sx_max	= [(b*b'*(1/4)*π*D^2) / (Av*Sy)]	=	309.5916	mm
Sx	=	=	300	mm

Shear Reinforcement Used **D16 - 300/600**

The following is a recapitulation of the reinforcement used in the superstructure of the bridge after the calculation,

Table 4.6 *Deck Slab Reinforcement*

Reinforcement Type	Specification
Axial - Flexure Reinforcement	D25 - 150
Transversal Reinforcement	D13 - 150
Shear Reinforcement	D16 – 300/600

Table 4.7 *Back Wall Reinforcement*

Reinforcement Type	Specification
Longitudinal Flexure Reinforcement	D19 - 150
Transversal Flexure Reinforcement	D13 - 150
Shear Reinforcement	D13 – 300/400

Table 4.8 *Wing Wall Reinforcement*

Reinforcement Type	Specification
Longitudinal Flexure Reinforcement	D16 - 150
Transversal Flexure Reinforcement	D13 - 150
Shear Reinforcement	D13 – 300/400

Table 4.9 *Approach Slab Reinforcement*

Reinforcement Type	Specification
Longitudinal Flexure Reinforcement	D16 - 200
Transversal Flexure Reinforcement	D13 - 200
Shear Reinforcement	D13 – 300/400

Table 4.10 *Pile Cap Reinforcement*

Reinforcement Type	Specification
Longitudinal Flexure Reinforcement	D25 - 150
Transversal Flexure Reinforcement	D19 - 150
Shear Reinforcement	D13 – 300/400

Table 4.11 *Pile Foundation Reinforcement*

Reinforcement Type	Specification
Axial - Flexure Reinforcement	16D25
Shear Reinforcement	D16 - 100

4.4. 3D MODELING OF PRESTRESSED CONCRATE BRIDGE USING AUTODESK REVIT 2023

After obtaining the results of the analysis of the superstructure, substructure, and foundation of the prestressed concrete bridge with output in the form of parameters that can be used in modeling the bridge such as the dimensions of the bridge structure components and the required number of these components, the next step is to make a 3D model of the bridge. The model to be made is only limited to modeling the structure and architecture of the prestressed concrete bridge. The software that will be used to create a 3D model of the bridge is Autodesk Revit 2023 as previously explained.

The stages that can be done in performing 3D modeling using Revit Autodex 2023 include the following.

4.4.1. 3D Modeling of Bridge Structural Components

1. Open Autodesk Revit 2023 installed on your PC. When the initial view of Revit 2023 appears, in the Model section, click New. Then the New Project dialog box will appear, on the File template select Metric-Construction Template, and on Create New select Project, and click OK as shown in the figure below.

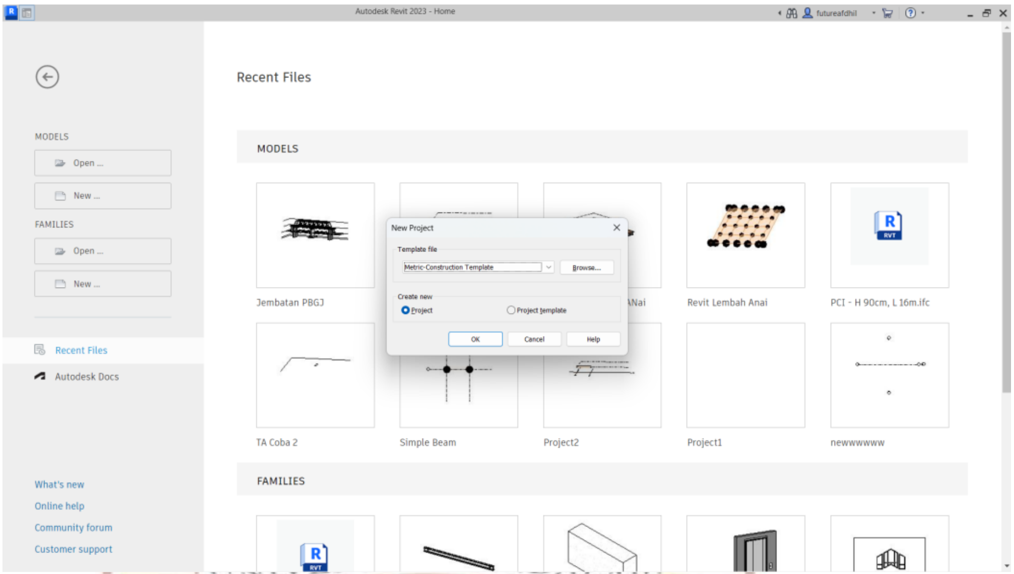

Figure 4.71 New Project

2. After that, the project display will appear according to the template that we have chosen previously as shown below, where there are restrictions on work or displays such as Level 1, Level 2, East, North, South, and West which we can later adjust as needed.

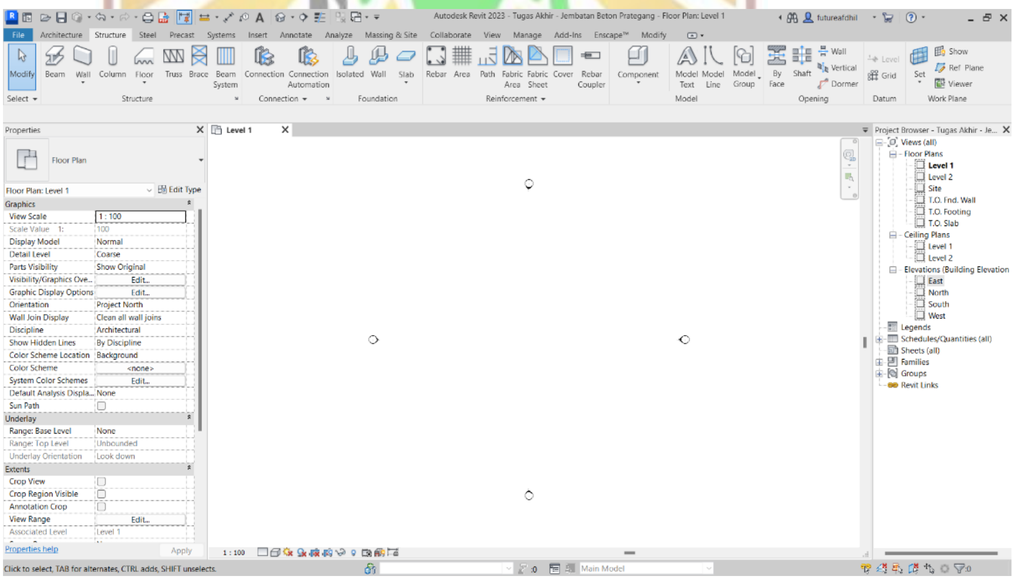

Figure 4.72 Worksheets of Autodesk Revit 2023

3. Next, enter one of the Floor plan worksheets to create a Grid that is used to help in creating drawings by selecting Datum > Grid on the Ribbon or you can type the shortcut "GR" and then arrange the grid according to the dimensions of the bridge that we will create as shown in the figure below.

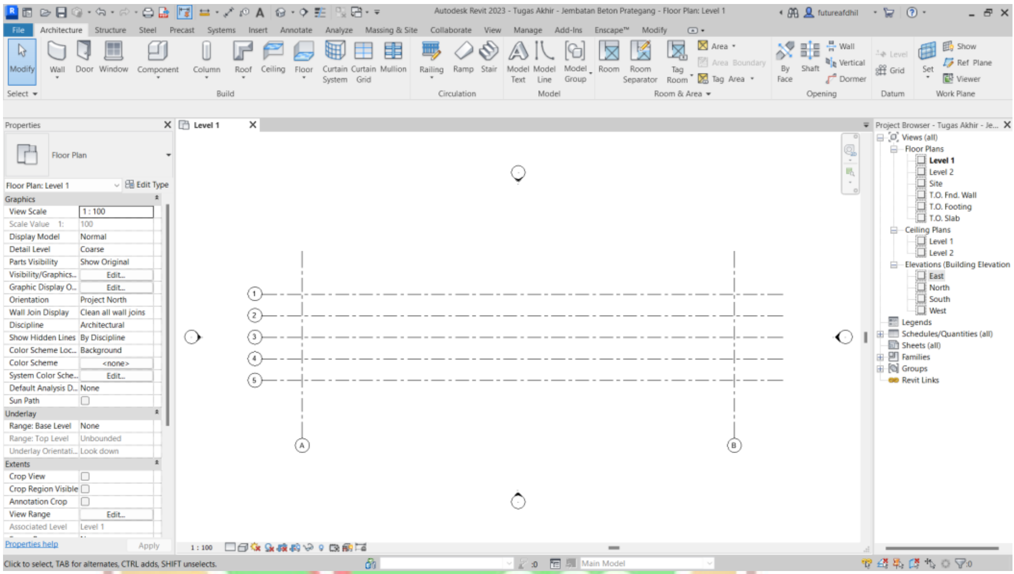

Figure 4.73 *Creating a Grid*

4. then enter one of the Elevations (Building Elevation) worksheets to create a Level Line by selecting Datum > Level on the Ribbon or you can type the Shortcut "LL" and then set the Line Level according to the dimensions of the bridge that we will create as show5n in the figure below.

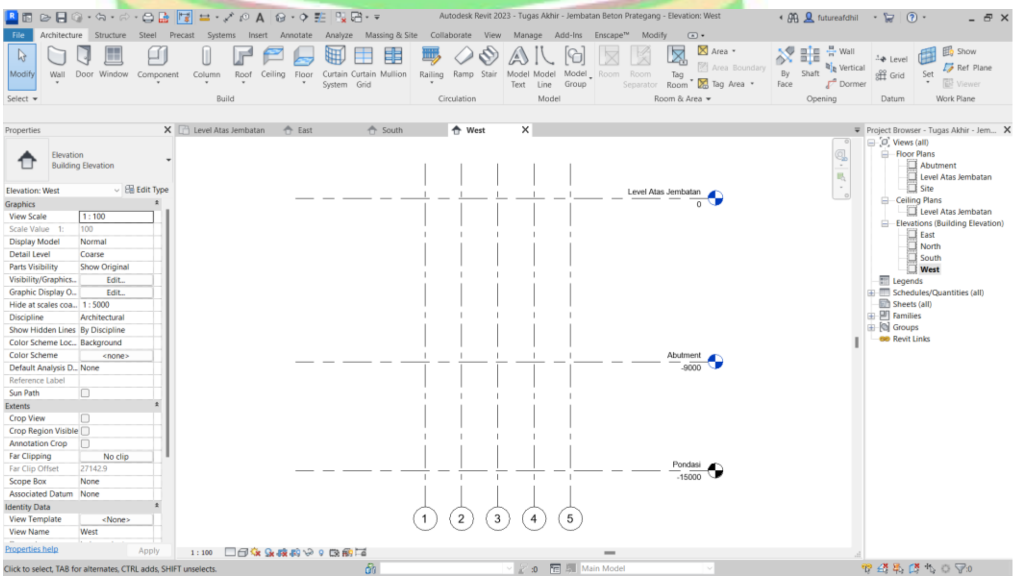

Figure 4.74 *Creating a Level Line*

5. Next, create a family of all bridge components to be modeled such as PCI-Girder, Tendon, Abutment, Sidewalk, and Barrier by selecting the file > New > Family and then after opening the dialog box, select the templates family according to the bridge component to be created. Then the bridge component in the family corresponds to the dimensions that have been obtained in the previous subchapter, then the result of the family of the bridge component will look like in the figure below.

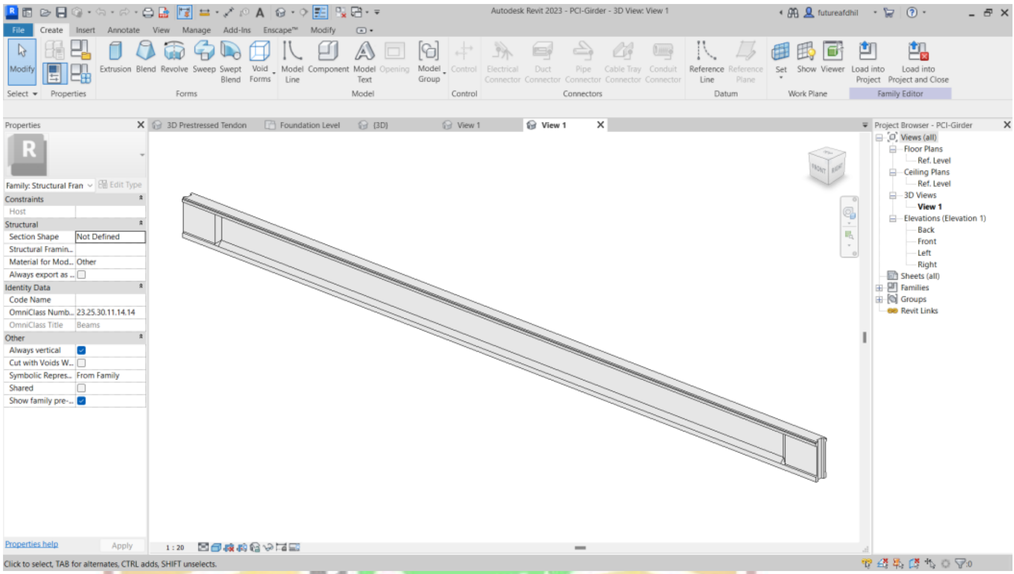

Figure 4.75 *Family PCI-Girder*

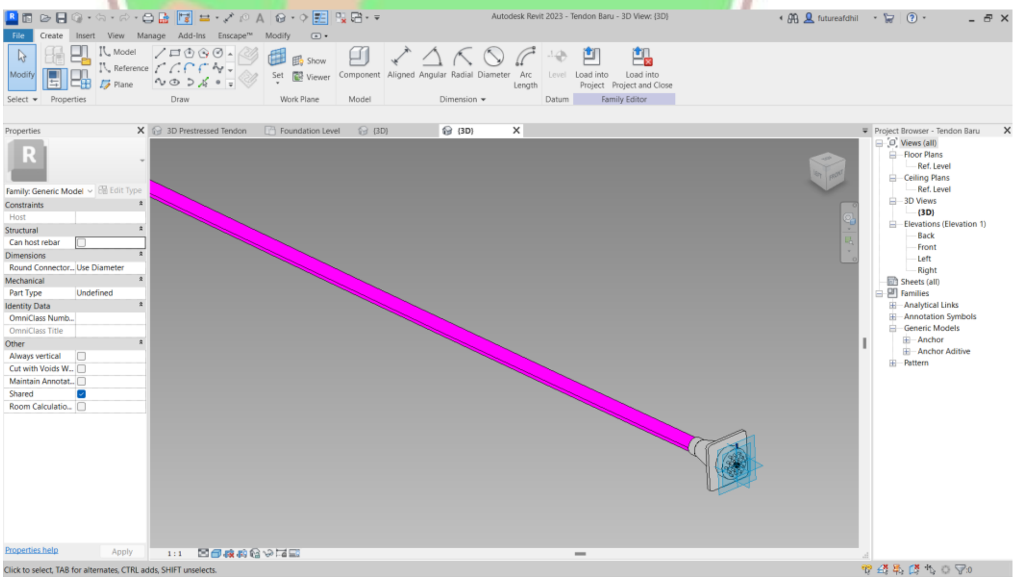

Figure 4.76 *Family Tendon and Anchor*

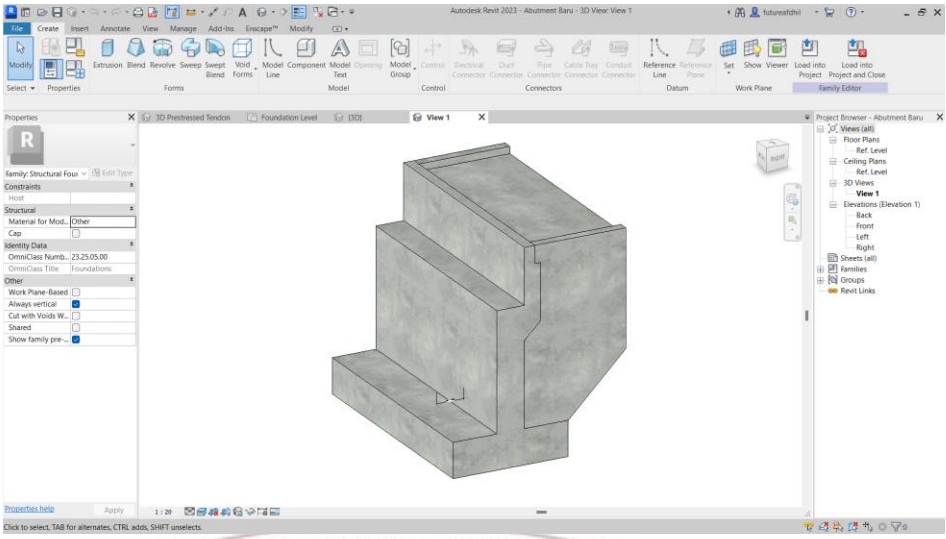

Figure 4.77 *Family Abutment*

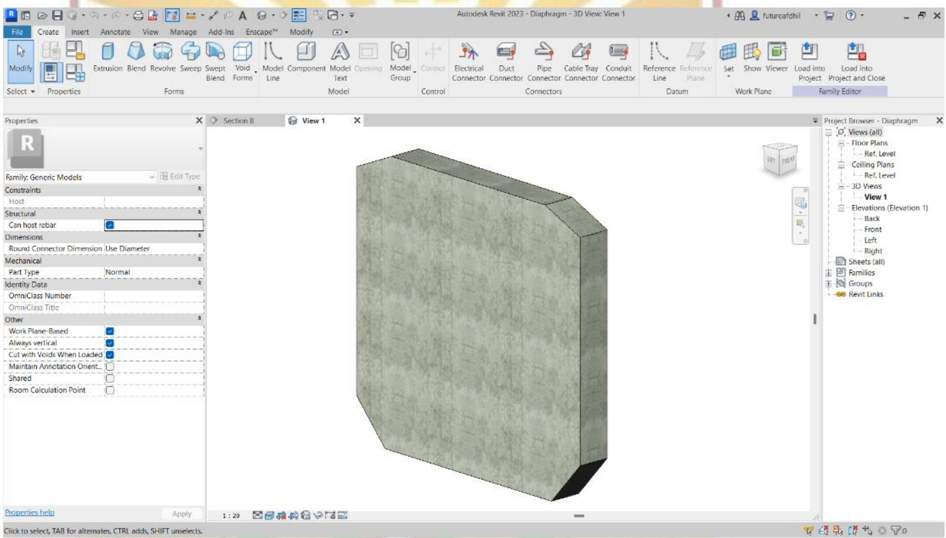

Figure 4.78 *Family Diaphragm*

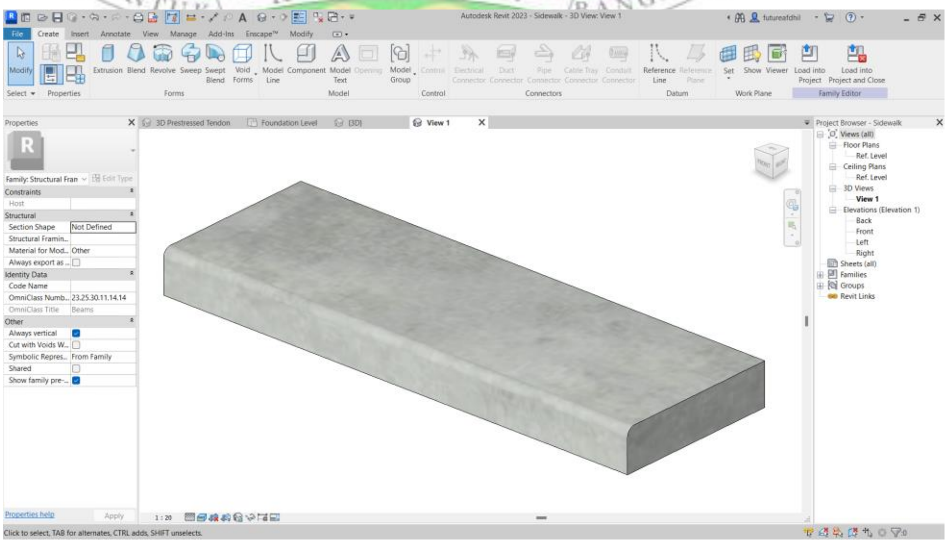

Figure 4.79 *Family Sidewalk*

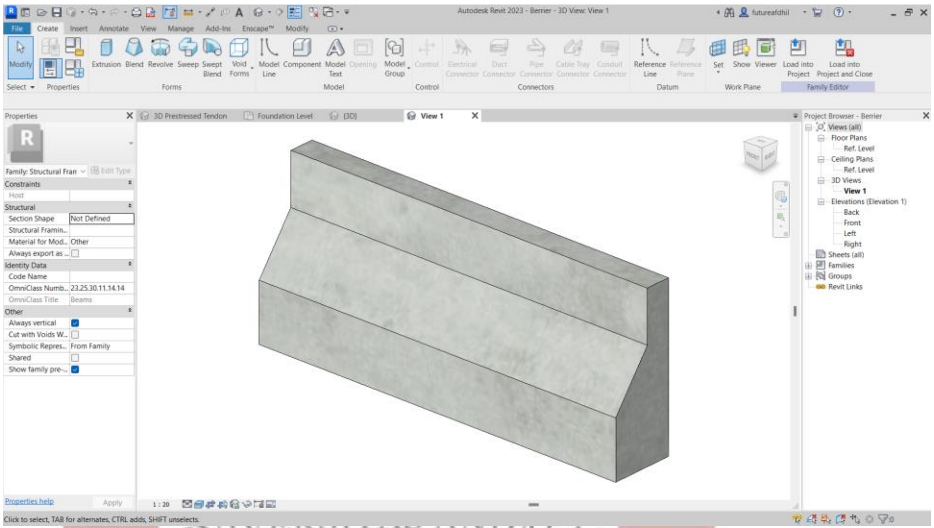

Figure 4.80 *Family Barrier*

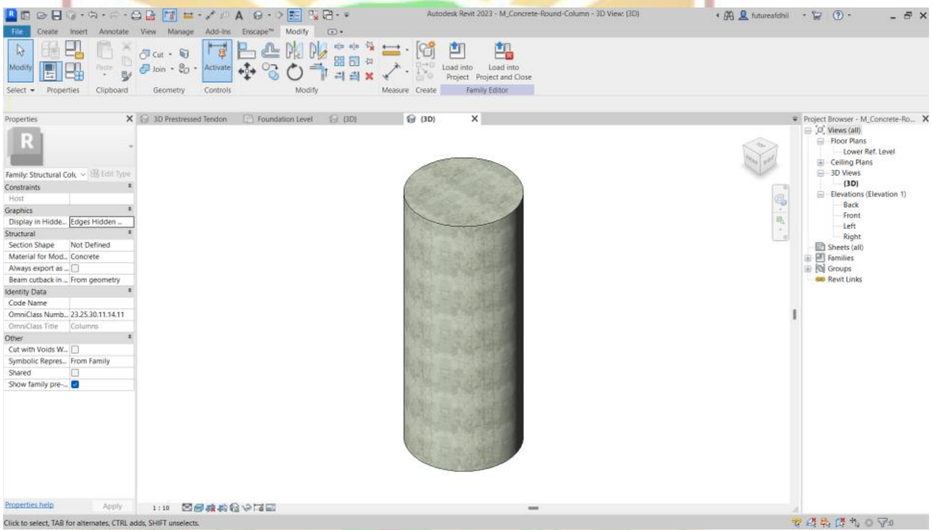

Figure 4.81 *Family Pile*

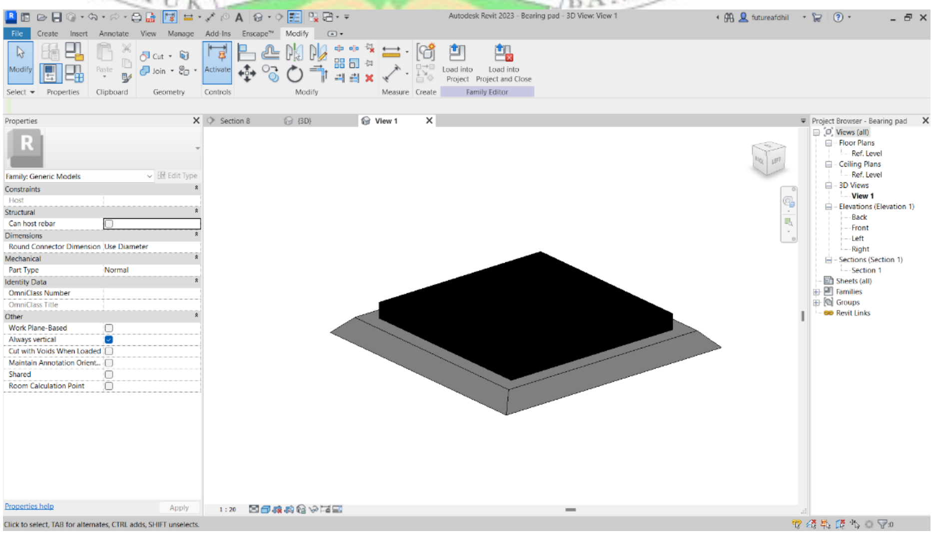

Figure 4.82 *Family Elastomer Bearing Pad*

6. Then input the family of all bridge components that have been made into the initial worksheet and adjust the location and number of bridge components according to the design that has been obtained previously, the result will look like in the figure below.

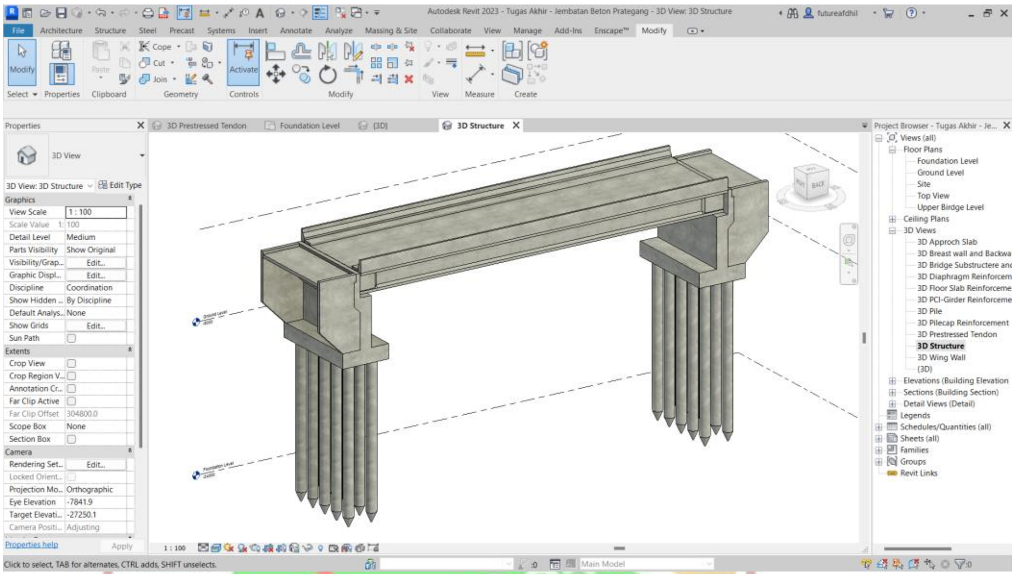

Figure 4.83 *3D Modeling of Bridge Structure*

7. To place the components of the tendon that has been made on, input the tendon family that has been created earlier and then adjust the placement of the tendon at the end and middle of the span according to the position of the tendon that has been planned as shown in the figure below

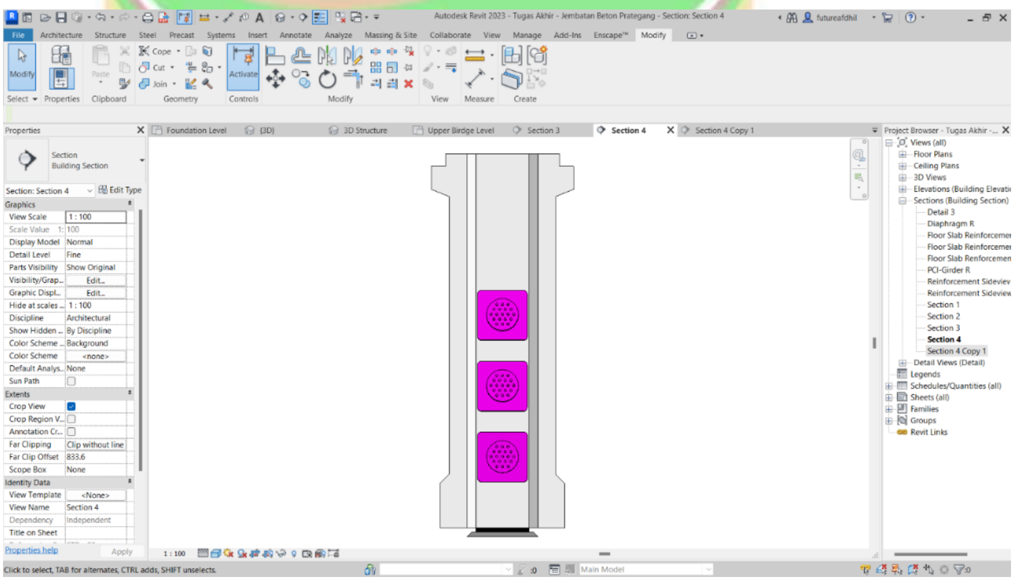

Figure 4.84 *Tendon Position in End of the Span*

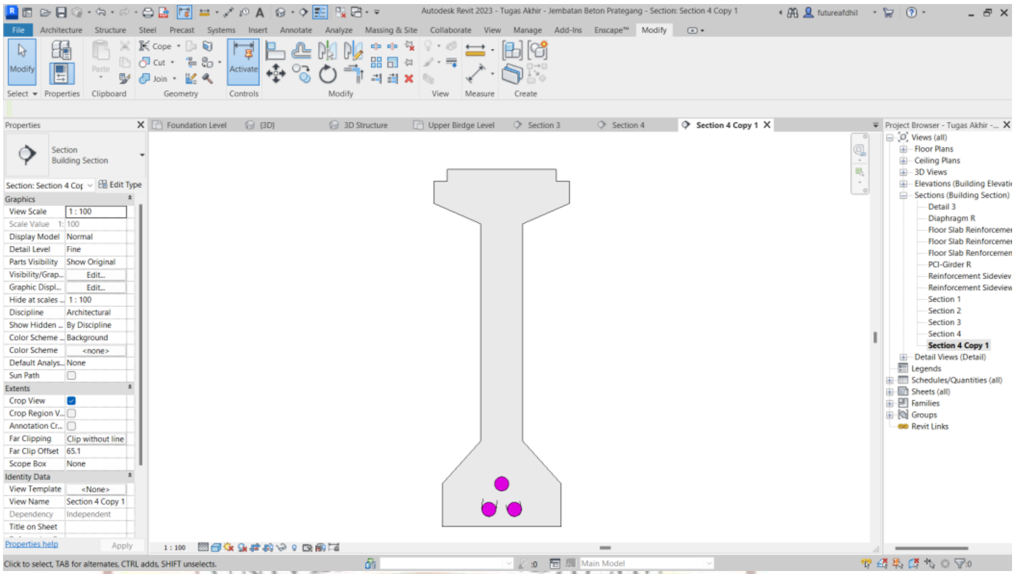

Figure 4.85 *Tendon Position in the Middle of the Span*

4.4.2. Modeling Reinforcement of Bridge Components

1. On the View Tab, click Section, on Properties select Detail View, and create a cut line on the object to be made of reinforcement, for example on the abutment as shown in the figure below.

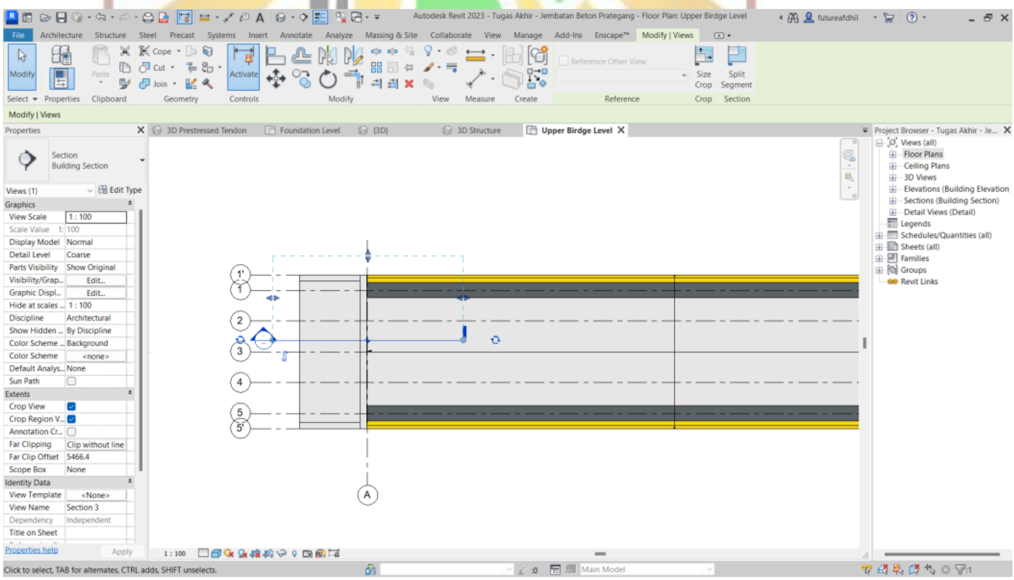

Figure 4 86 *View – Section – Detail View*

2. The next step is to right-click on the Detail View and click Go to View so that a display of object pieces will appear as shown in the figure below.

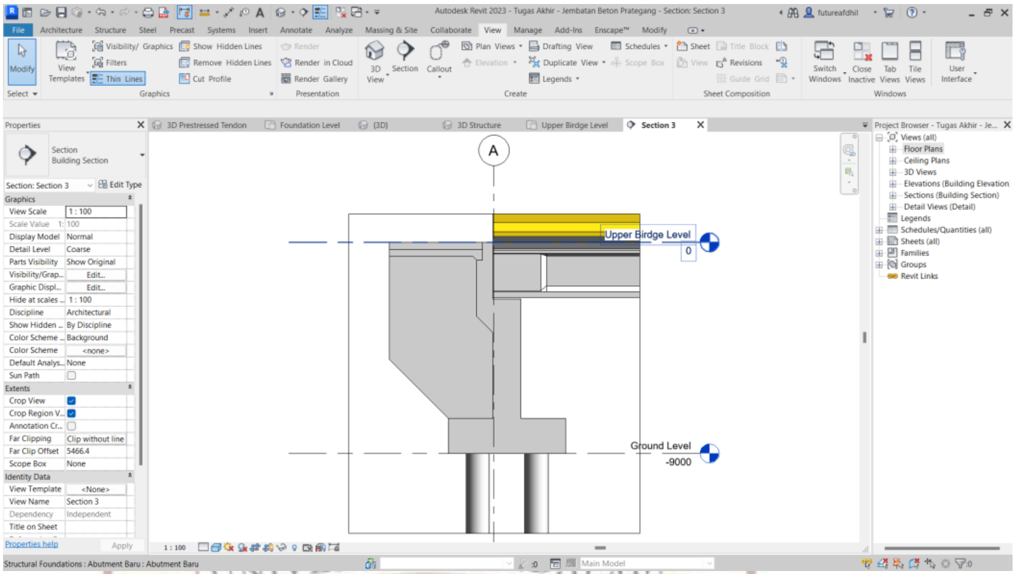

Figure 4.87 *Detail View*

3. To make a concrete blanket arrangement, it can be done by clicking the Structure tab, clicking Cover, selecting the desired type of concrete cover, then clicking on the object that will be arranged for the concrete cover as shown in the figure below.

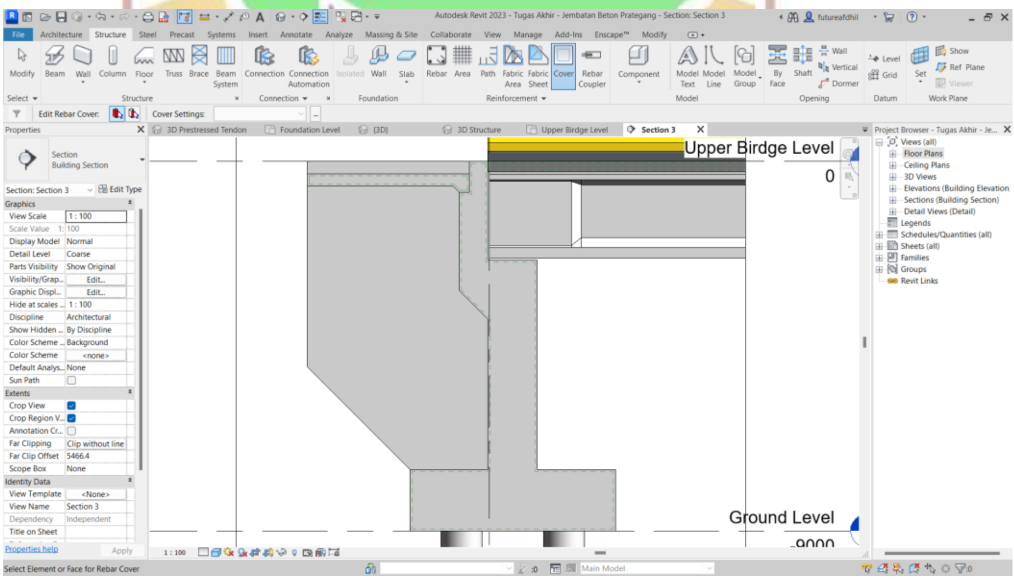

Figure 4.88 *Structure – Cover*

4. Next, make the shape of the reinforcement following the provisions that have been made previously by clicking the Structure Tab, and clicking Rebar, then several types of pre-existing reinforcement will appear as seen in the figure below.

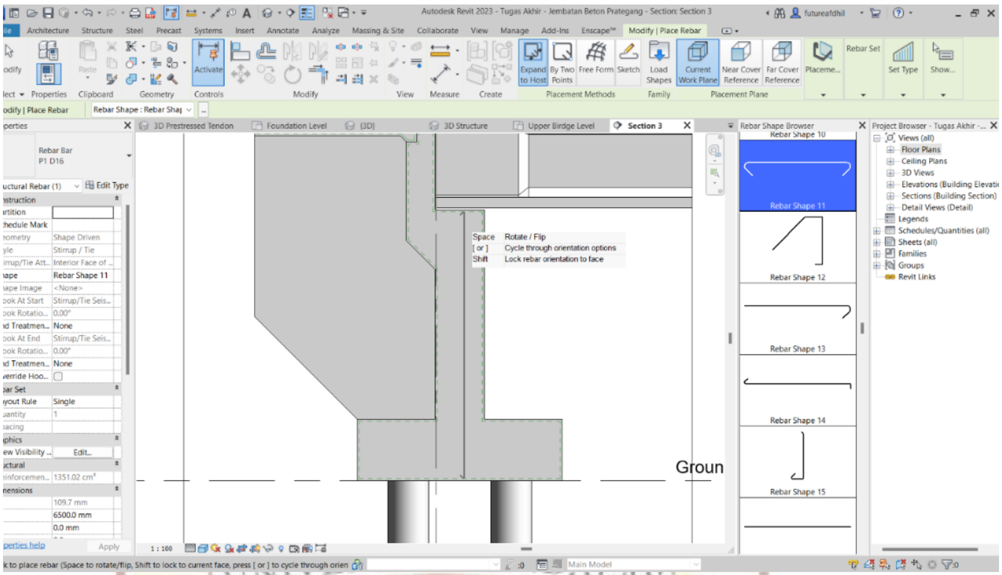

Figure 4.89 *Structure – Rebar*

5. If the shape of the reinforcement is not available in the existing type of reinforcement, then we can make the shape of the reinforcement according to our will by clicking Sketch, and then drawing the shape of the reinforcement that has been predetermined. If it is finished, then the thing that needs to be regulated is the number of rebars that exist with the distance of each of the rebars. This can be done by clicking on the previously made reinforcement, on the Layout Tab selecting Maximum Spacing, then setting the maximum spacing between the reinforcements as, for example, D19 150 reinforcement, then the distance between the reinforcements is 150 mm so that it can look like in the figure below.

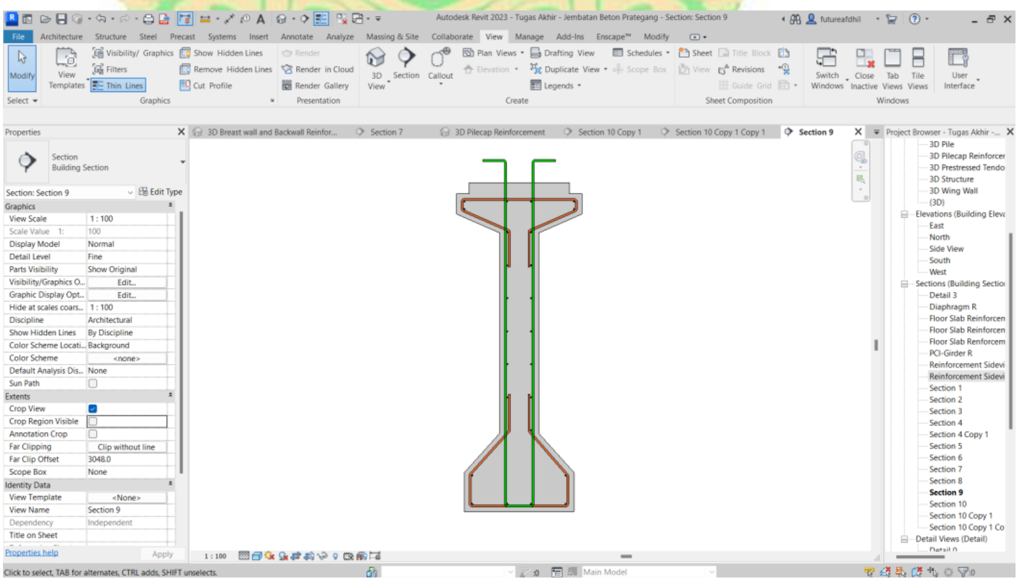

Figure 4 90 *PCI-Girder Reinforcement*

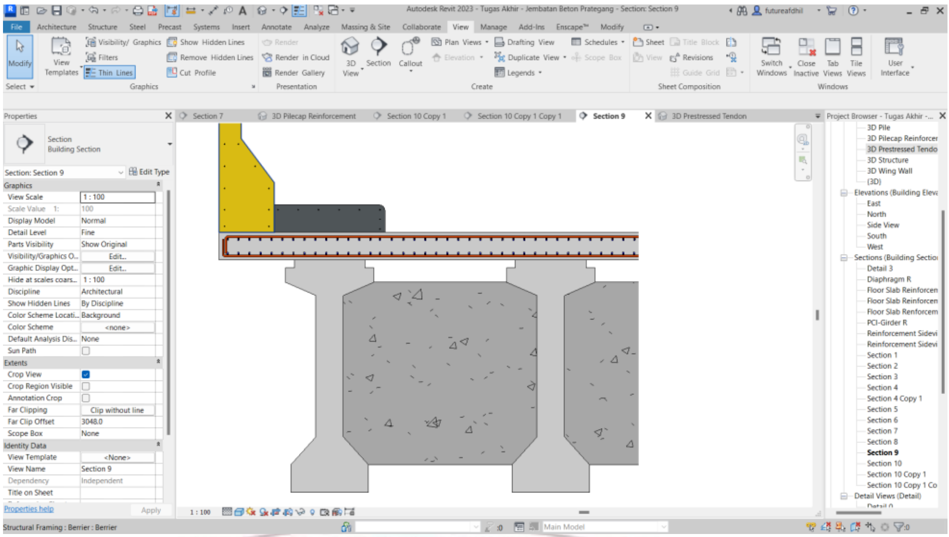

Figure 4.91 *Floor Slab Reinforcement*

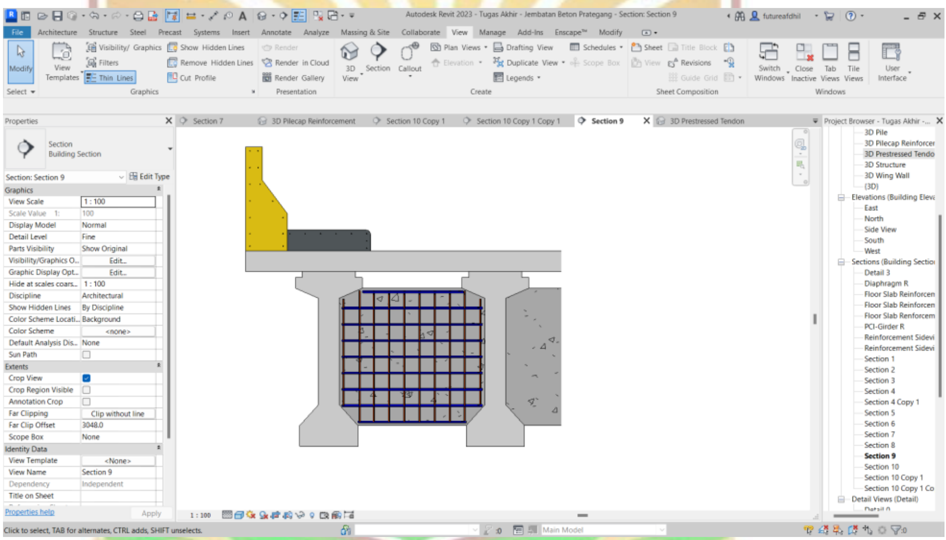

Figure 4. 92 *Diafragm Reinforcement*

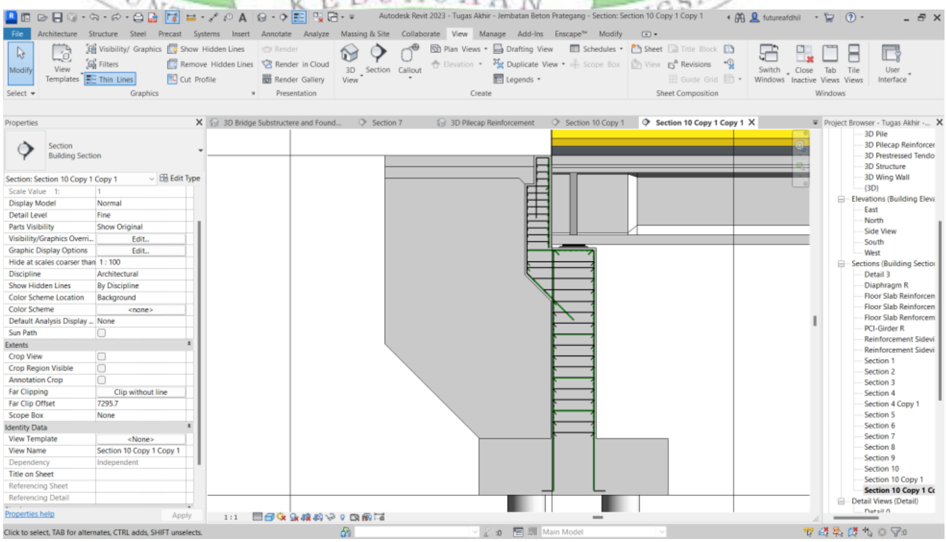

Figure 4.93 *Breast Wall and Back Wall Reinforcement*

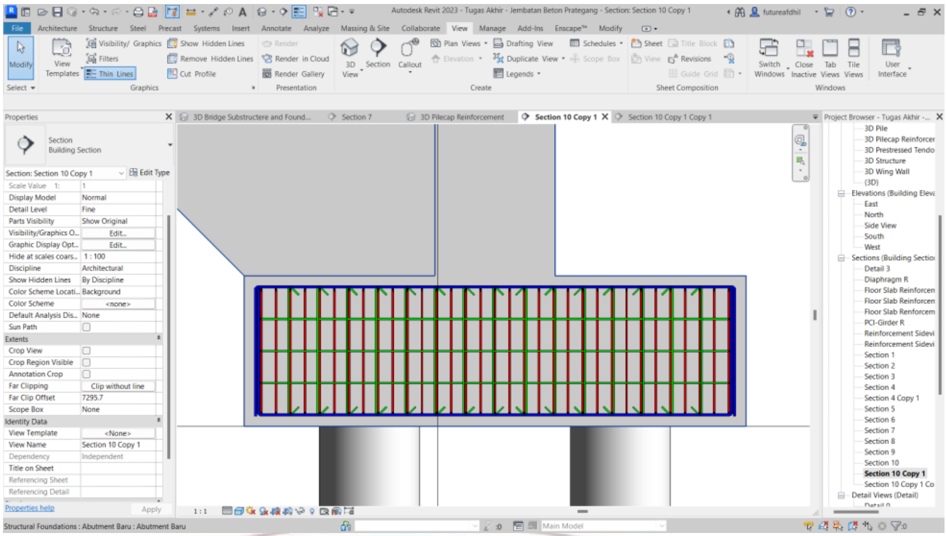

Figure 4.94 *Pile Cap Reinforcement*

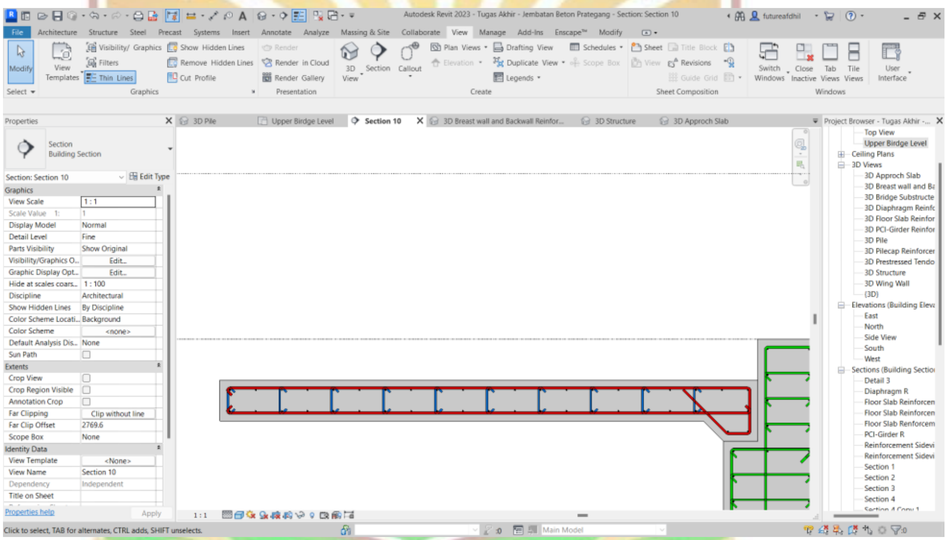

Figure 4.95 *Approach Slab Reinforcement*

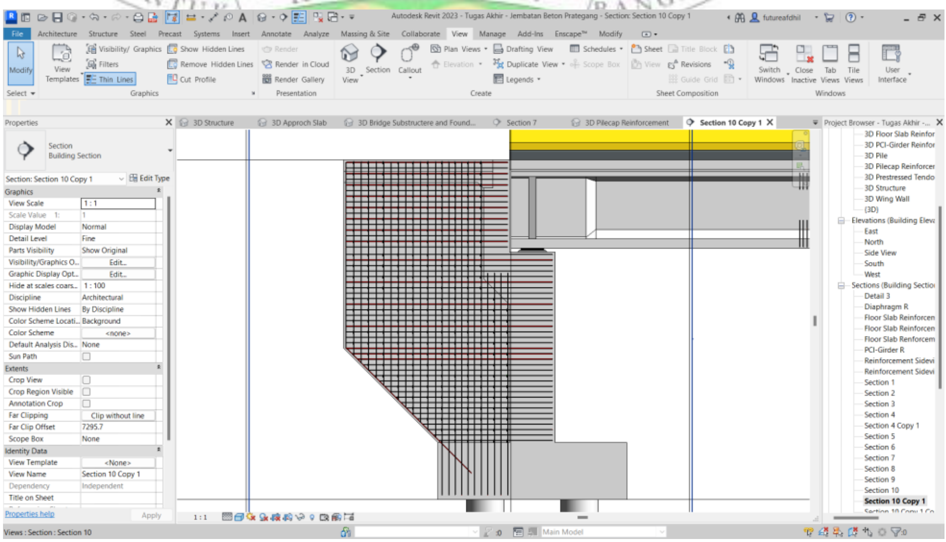

Figure 4.96 *Wing Wall Reinforcement*

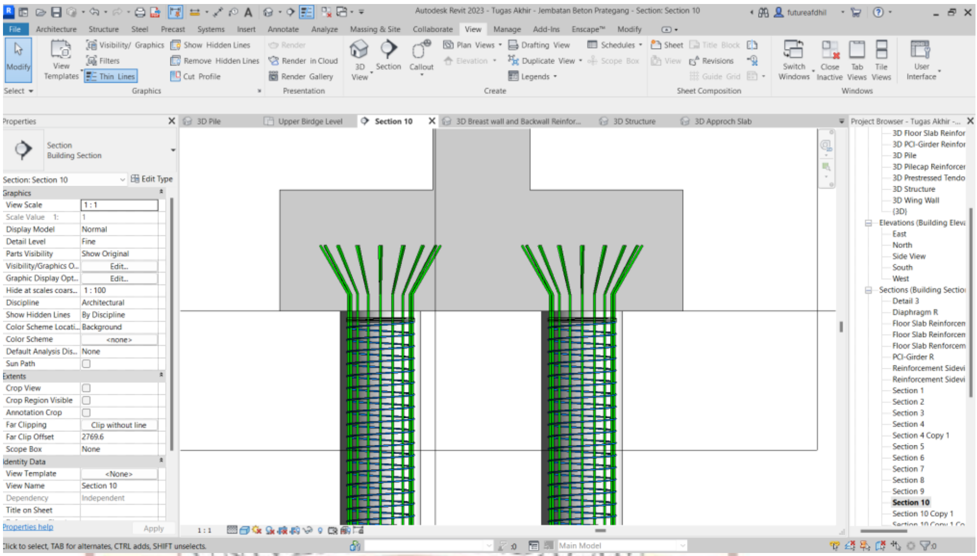

Figure 4 97 *Pile Reinforcement*

6. For detailed drawings, it will be displayed in the attachment and the following is a complete view of the bridge structure that has been modeled using Autodesk Revit 2022 with the reinforcement that exists on the bridge component as shown in the Figure below.

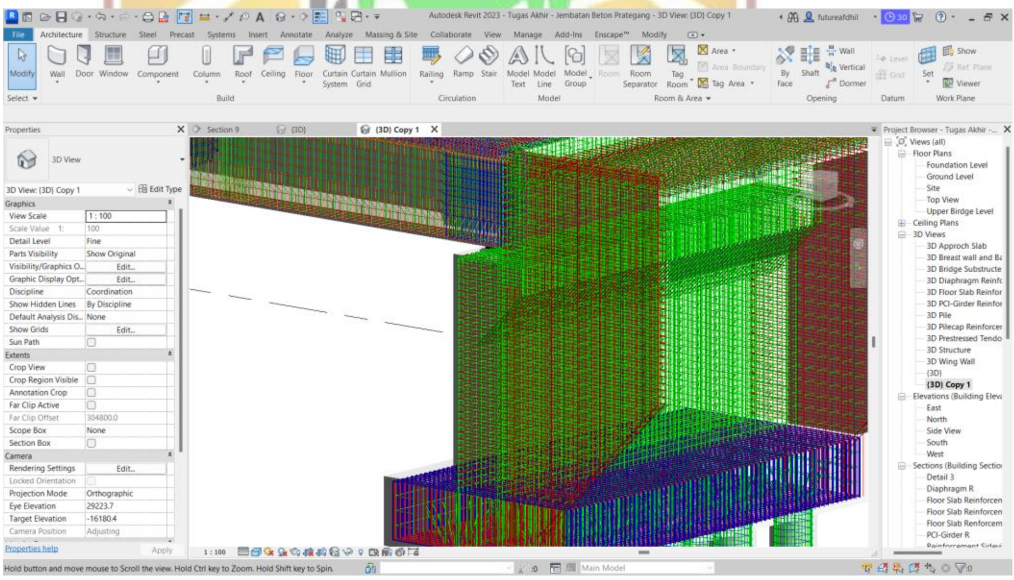

Figure 4.98 *Bridge Reinforcement*

CHAPTER V
CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

After researching the planning and design of pre-stressed concrete bridges with the application of the Building Information Modeling (BIM) concept to assist in the calculations, design process, and modeling, the conclusions that can be taken from this research are,

1. This research successfully designed a prestressed concrete bridge that can withstand various types of loads that may work, both dead loads, live loads, and other environmental loads. The planning process is carried out by considering structural and safety factors, resulting in a design that can meet the technical standards required to maintain the integrity and safety of the bridge during its service life. The right selection of materials and the efficient design of structural elements also contribute to the stability and durability of the bridge.
2. The deflection that occurs on the bridge (δ_{max}) based on calculations in Midas Civil 2023 must be smaller than the allowable deflection (L/360) with the following values,

   $$\delta_{max} \leq L/360$$

   $$61.361 \text{ mm} \leq 111.111 \text{ mm}$$

   So the bridge structure can withstand all the loads without experiencing too large deflection.
3. The design of prestressed concrete uses a PCI-Girder type 2100 mm with 57 Strands and 3 Tendons, where each Tendon has 19 Strands
4. From the results of the planning and design of the prestressed concrete bridge, this research succeeded in producing a detailed engineering design (DED) that covers all technical and geometric aspects of the bridge structure will be presented in the attachment. The resulting DED includes dimensional specifications of structural elements, material selection, and clear structural detailing in 2D and 3D form. This design is ready to be used as a guide in the implementation of bridge construction in the field. A complete and accurate DED will also minimize the potential for errors during execution, thereby improving the quality and efficiency of construction.

5. The application of the BIM concept in the planning and design of prestressed concrete bridges provides convenience in calculating and modeling structures more efficiently and accurately. With BIM, any changes to the design can be instantly and automatically updated across the entire model, reducing the potential for calculation and modeling errors.

6. The application of BIM in the planning and design of prestressed concrete bridges provides some significant advantages, including:
   - BIM allows for more accurate calculations and more efficient modeling, reducing the possibility of design errors and structural miscalculations.
   - BIM allows designers to analyze various design scenarios and select the optimal solution. For example, in the planning of prestressed concrete bridges, BIM can be used to optimize the dimensions of structural elements, material types, and prestressed cable configurations, so that material efficiency and structural strength can be better achieved.
   - With BIM, load simulation and structural response to dynamic or static loads can be done better. This is very important in the planning of a prestressed concrete bridge that must be able to withstand the load from vehicles, wind, and other loads.
   - BIM technology provides the ability to view 3D models of the entire bridge, which makes it easier to understand and communicate between the design team and other stakeholders.

7. The implementation of BIM also has several challenges and advantages, such as:
   - BIM implementation requires a considerable initial investment, both in terms of software, hardware, and training of human resources who will operate the BIM system.
   - The use of BIM requires higher technical expertise compared to conventional methods. Therefore, it takes a very long time to learn the BIM-based software.
   - If the BIM-based software used comes from a different development, the data transfer cannot be done directly. An add-on tool is needed to do just that, or the data transfer is done manually.

5.2 RECOMMENDATION

Suggestions that can be given for further research related to this research include the following.

1. Future research can explore variations in the use of materials in prestressed concrete bridge components, such as the quality of concrete used or prestressing systems with other cable materials.
2. To extend this research, it is recommended to design prestressed concrete bridges with longer spans. or across areas with more complex conditions.
3. It is recommended to explore other types of prestressed concrete girders, such as T-Girders or U-Girders, to evaluate their efficiency and suitability for different bridge designs and conditions.
4. Future research can investigate the design of other bridge types, such as cable-stayed bridges, steel composite bridges, or suspension bridges.

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ATTACHMENT

ATTACHMENT I

MANUAL CALCULATION

ATTACHMENT II

STRUCTURAL ANALYSIS OF THE BRIDGE SUPERSTRUCTURE USING MIDAS CIVIL 2022

ATTACHMENT III

STRUCTURAL ANALYSIS OF THE BRIDGE SUBSTRUCTURE AND FOUNDATION USING MIDAS CIVIL 2022

ATTACHMENT IV

STRUCTURE DRAWING

ATTACHMENT V

DETAIL STRUCTURE DRAWING

Bridge General Data

Dimension of Bridge

Length of Bridge	: L	=	40.00 m
Width of Bridge	: B_L	=	10.00 m
Width of Bridge Lines	: B_{BL}	=	2 x 3.5 m
Thickness of Wearing Surface	: t_a	=	0.05 m
Width of Sidewalk	: b_s	=	1.00 m
Thickness of Sidewalk	: t_s	=	0.25 m
Width of Berrier	: b_b	=	0.50 m
Heigth of Berrier	: h_b	=	1.25 m

Data for Bridge Structure

Data for Bridge Superstructure

1. Concrate Girder Material Data

Compressive Strength of Concrete at 28 Days	: f'cg	=		50 MPa
Compressive Strength of Concrete During Stressing	: f'cig	=		40 MPa
Modulus of Elasticity of Concrete at 28 Days	: Ecg	=	[4700 √ f'cg]	33234.02 MPa
Modulus of Elastisity of Concrete During Stressing	: Ecig	=	[4700 √ f'cig]	29725.41 MPa
Specific Gravity of Concrete	: γc	=		25 kN/m^3

2. Bridge Floor Slab Data

Compressive Strength of Concrete at 28 Days	: f'cd	=		35 MPa
Compressive Strength of Concrete When First Loaded	: f'cid	=		30 MPa
Modulus of Elasticity of Concrete at 28 Days	: Ecd	=	[4700 √ f'd]	27805.57 MPa
Modulus of Elasticity of Concrete When First Loaded	: Ecid	=	[4700 √ f'id]	25742.96 MPa
Specific Gravity of Concrete	: γc	=		25 kN/m^3

3. Pre-Stressed Steel Data

Type of Strand	: Seven Wire Strand, Low Relaxation			
Pre-Stressed Steel Grade	: ASTM 416			
Diameter of Strand	: Dps	=		12.70 mm
Cross-Sectional Area of Strand	: Aps	=		98.71 mm^2
Tensile Strength of Pre-Stressed Steel	: fpu	=		1860 MPa
Yield Strength of Pre-Stressed Steel	: fpy	=	[0.9 fpu]	1674 MPa
Modulus of Elasticity of Pre-Stressed Steel	: Eps	=		197000 MPa
Jacking Force	: fpbt	=	[0.75 fpu]	1395 MPa

4. Steel Reinforcement Data

Steel Reinforcement Grade (for D ≥ 13 mm)	: BJTD 42		
Yield Strength of Reinforcement Steel	: fy	=	420 MPa
Tensile Strength of Reinforcement Steel	: fu	=	525 MPa
Modulus of Elasticity of Reinforcement Steel	: Es	=	200000 MPa
Steel Reinforcement Grade (for D < 13 mm)	BJTP 24		
Yield Strength of Reinforcement Steel	: fy	=	240 MPa
Tensile Strength of Reinforcement Steel	: fu	=	390 MPa
Modulus of Elasticityof Reinforcement Steel	: Es	=	200000 MPa

4. Elastomeric Bearing Pad Data				
Length of Elastomer Bearing	: L		600	mm
Width of Elastomer Bearing	: W	=	600	mm
Thickness of Elastomer Bearing	: H	=	97	mm
Thickness Upper and Lower Elastromer Bearing	: Hc		6	mm
Thickness of One Elastomer Layer	: Hri	=	15	mm
Number of Elastomer Layer	: Nri		4	
Thickness of One Steel Reinforcement Layer	: Hs		5	mm
Number of Steel Reinforcement	: Ns	=	5	
Shape Factor	: S	=	10	
Compressive Stiffness	: SDc	=	1.56E+06	kN/m
Shear Stiffness	: SDs		3.85E+03	kN/m
Allowable Compressive Strength	: Pn		2930	kN

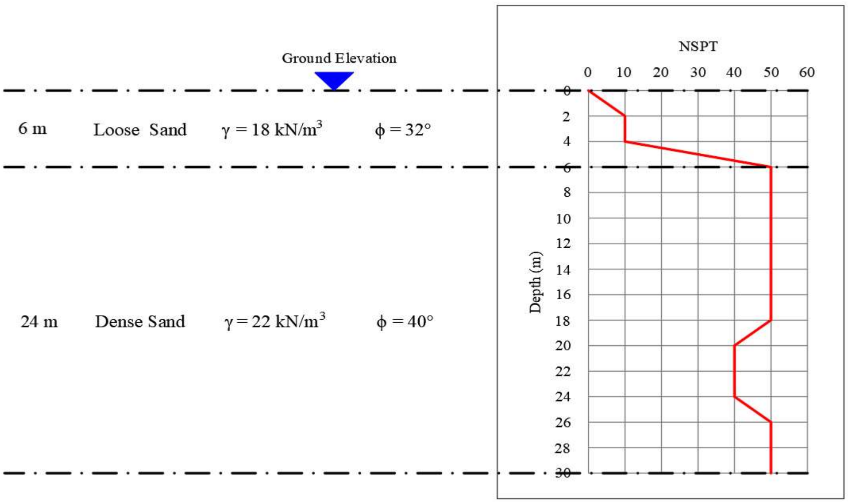
Data for Bridge Substructure

1. Soil Data				
Specific Gravity of Soil	: γ_{soil}	=	18	kN/m^3
Angle of Internal Friction	: ϕ	=	30	°
Cohesion of Soil	: C	=	1	kN/m^2

2. Material Data				
Compressive Strength of Concrete	: f'c	=	30	MPa
Modulus of Elasticity of Concrete	: Es	= [4700 √ f'c]	25742.96	MPa
Specific Gravity of Concrete	: γc	=	24	kN/m^3
Steel Reinforcement Grade	: BJTD 420			
Yield Strength of Rainforcement Steel	: fy	=	420	MPa
Tensile Strength of Rainforcement Steel	: fu	=	525	MPa
Modulus of Elasticity of Rainforment Steel	: Es	=	200000	MPa

Data for Foundation

1. N-SPT Data of Soil



2. Material Data of the Foundation				
Compressive Strength of Concrate	: f'c	=	30	MPa
Modulus of Elasticity of Concrate	: Es	=	25742.96	MPa
Specific Grafity of Concrate	: γc	=	24	kN/m^3

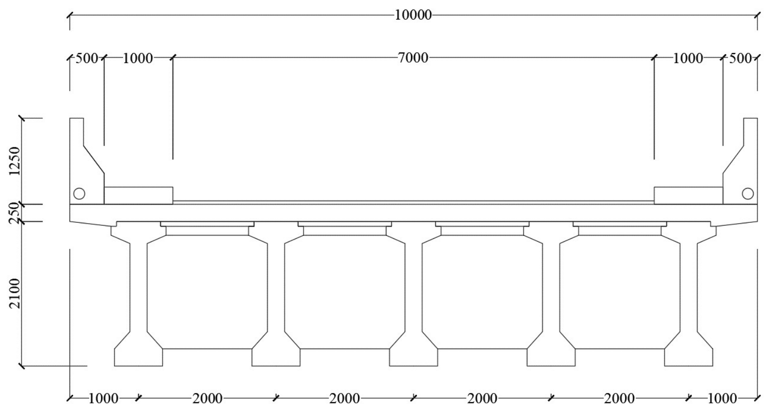
3. Dimension of the Foundation				
Diameter of Foundation	: f'c	=	0.80	m
Depth of Foundation	: Es	=	15.00	m

Preliminary Design of Bridge Superstructure

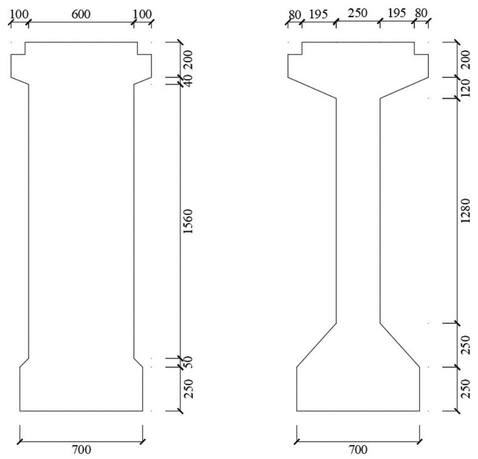
1. Preliminary Design

Birdge Length	**: L**	=		40 **m**
Minimum Height of Deck System	**: Hd**	=	[0.045 L]	1800 **mm**
Type of Prestressed Girder	**: PCI-Girder 2100 mm**			
Spasi Antar Gelagar	**: S_g**	=	[1100 mm ≤ Sg ≤ 4900 mm]	2000 **mm**
Thickness of Floor Slab	**: t_s**	=	[110 mm ≤ Sg ≤ 300 mm]	250 **mm**
Cantilevered Floor Slab Length	**: d_e**	=	[$-300 \le de \le 1700$]	1000 **mm**
Number of Girder	**: n^g**	=		5 **buah**
Width of Highwey	**: W_t**	=		7000 **mm**
Width of Sidewalk	**: W_s**	=		1000 **mm**
Width of Berrier	**: W_b**	=		500 **mm**
Thickness of Diaphram	**: t_d**	=		200 **mm**

2. Cross-Section of Bridge



3. Non-Composite Cross Section of Girder



Loading of Bridge Superstucture

1. Dead Load from Self Weight (MS)

Load caused by the weight of the bridge structure itself

2. Additional Dead Load From Berrier and Sidewalk (MA_1)

Material of Berrier and Sidewalk	: **Concrate**			
Specify Gravity of Material	: **γc**	=	24	**kN/m^3**
Cross-Sectional Area of Berrier and Sidewalk	: **A_{BS}**	= [Approximate calculation]	0.65	**m^2**
Load From Berrier and Sidewalk	: **L_1**	= [γc * A_{BS}]	15.6	**kN/m**

3. Additional Dead Load From Wearing Surface (MA_2)

Material of Wearing Surface	: **Asphalt**			
Specify Gravity of Material	: **γa**	=	22	**kN/m^3**
Thickness of Wearing Surface	: **ta**	= [Initial Data]	0.05	**m**
Load From Wearing Surface	: **L_2**	= [γc * ta]	1.1	**kN/m^2**

4. Line Load (TD)

8.3.1 Intensitas beban "D"

Beban terbagi rata (BTR) mempunyai intensitas *q* kP_a dengan besaran *q* tergantung pada panjang total yang dibebani *L* yaitu seperti berikut :

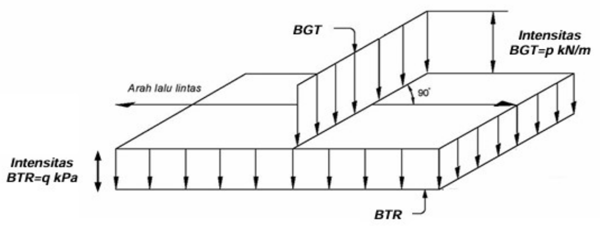
Jika $L \leq 30$ m : $q = 9{,}0$ kPa (27)

Jika $L > 30$m : $q = 9{,}0\left(0{,}5+\frac{15}{L}\right)$ *kPa* (28)

Keterangan:

q adalah intensitas beban terbagi rata (BTR) dalam arah memanjang jembatan (kPa)

L adalah panjang total jembatan yang dibebani (meter)



Gambar 24 - Beban lajur "D"

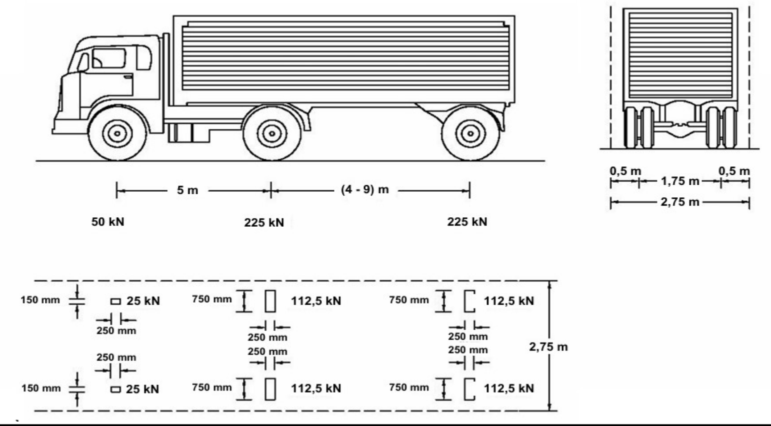
Beban garis terpusat (BGT) dengan intensitas *p* kN/m harus ditempatkan tegak lurus terhadap arah lalu lintas pada jembatan. Besarnya intensitas *p* adalah 49,0 kN/m. Untuk mendapatkan momen lentur negatif maksimum pada jembatan menerus, BGT kedua yang identik harus ditempatkan pada posisi dalam arah melintang jembatan pada bentang lainnya.

Length of Bridge	: **L**	= [Initial Data]	40.00	**m**
Width of One Bridge Lines	: **B_{BL}**	= [Initial Data]	3.50	**m**
Uniformly Distributed Load	: **BTR'**	= [9 * (0.5 + (15 / L))]	7.875	**kN/m^2**
Concentrated Line Load	: **BGT'**	= [SNI 1725-2016]	49	**kN/m**
Dynamic Load Factor for Line Load	**FBD_{TD}**	= [SNI 1725-2016]	1.4	
Uniformly Distributed Load Inputted	: **BTR'**	= [BTR * B_{BL} * FBD_{BTR}]	38.588	**kN**
Concentrated Line Load Inputted	: **BGT'**	= [BGT * B_{BL} * FBD_{BGT}]	240.10	**kN**

5. Truck Load (TD)

8.4 Beban truk "T" (*TT*)

Selain beban “D”, terdapat beban lalu lintas lainnya yaitu beban truk "T". Beban truk "T" tidak dapat digunakan bersamaan dengan beban “D”. Beban truk dapat digunakan untuk perhitungan struktur lantai. Adapun faktor beban untuk beban “T” seperti terlihat pada Tabel 13.



Dynamic Load Factor for Truck Load	: FBD_{TT}	1.3

6. Pedestrian Load (TP)

8.9 Pembebanan untuk pejalan kaki (*TP*)

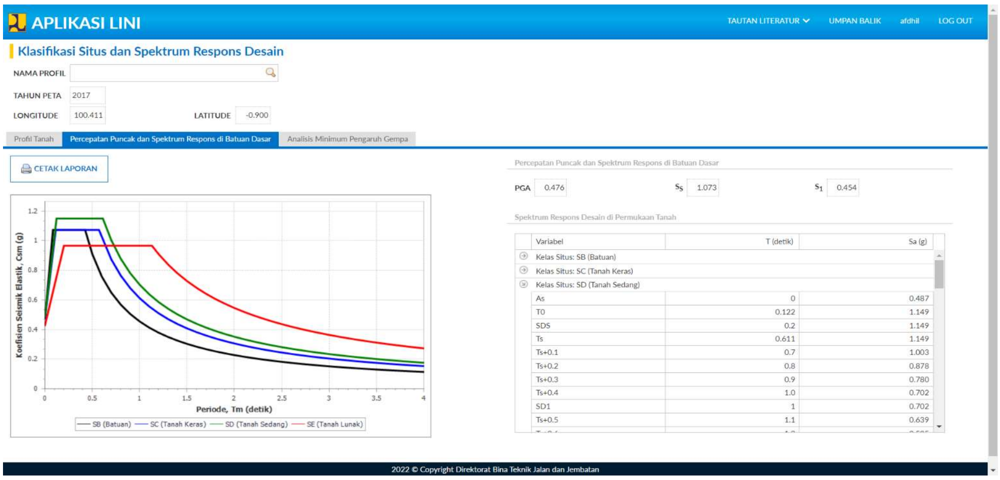
Semua komponen trotoar yang lebih lebar dari 600 mm harus direncanakan untuk memikul beban pejalan kaki dengan intensitas 5 kPa dan dianggap bekerja secara bersamaan dengan beban kendaraanpada masing-masing lajur kendaraan. Jika trotoar dapat dinaiki maka beban pejalan kaki tidak perlu dianggap bekerja secara bersamaan dengan beban kendaraan. Jika ada kemungkinan trotoar berubah fungsi di masa depan menjadi lajur kendaraan, maka beban hidup kendaraan harus diterapkan pada jarak 250 mm dari tepi dalam parapet untuk perencanaan komponen jembatan lainnya. Dalam hal ini, faktor beban dinamis tidak perlu dipertimbangkan.

Pedestian Load	: W_{TP}	=	5.00	kN/m^2
Width of Sidewalk	: b_s	= [Initial Data]	1.00	m
Distance Between Nodes	: Dn	= [Midas Modeling]	2.00	m
Point Load on the Central Node	: P1	= [W_{TP} * b_s * Dn]	10	kN
Point Load on the Edge Node	: P2	= [0.5 * P1]	5	kN

7. Wind Load on Structure (EWL)

Upstream Surface Conditions	: Open Field			
Wind Friction Speed	: Vo	= [SNI 1725-2016]	13.2	km/H
Length of Friction Upstream of the Bridge	: Zo	= [SNI 1725-2016]	70	mm
Elevation of Structures above Ground	: Z	= [Input]	9000	mm
Wind Speed Design of 10000 mm above Ground	: V_B	= [SNI 1725-2016]	90	Km/H
Wind Speed at an Elevation of 10000 mm above Ground	: V_{10}	= [SNI 1725-2016]	90	Km/H
Base Wind Preasure	: P_B	= [SNI 1725-2016]	0.0024	MPa
Wind Speed Design	: V_{DZ}	= [$2.5 * Vo *(V_{10}/V_B) * \ln(Z/Zo)$]	160.264	Km/H
Wind Load on Structures	: EWL	= [$P_B * (V_{DZ} / V_B)^2$]	7.610	Km/H

8. Earthquake Load (From Aplikasi Lini)



Peak Ground Acceleration	**: GPA**	= [Aplikasi Lini]	0.476	**m/s^2**
Spectral Response Acceleration at Short Period	**: S_S**	= [Aplikasi Lini]	1.073	**m/s^2**
Spectral Response Acceleration at 1-Second Period	**: S_1**	= [Aplikasi Lini]	0.454	**m/s^2**

Bridge Superstucture Analysis with Midas Civil 2022

Approximate Prestressing Force and Determination of The Number of Tendon

1. PCI-Girder Data (Non-Composite Girder)

Cross-Sectional Area	**: Ag**	= [Calculation Result of Midas CIvil 2022]	835250	**mm^2**
Momen of Inertia	**: Ig**	= [Calculation Result of Midas CIvil 2022]	4.40E+11	**mm^4**
Hight of Girder	**: hg**	= [Calculation Result of Midas CIvil 2022]	2100	**mm**
Distance from the Neutral Axis to the Bottom Fiber	**: yb**	= [Calculation Result of Midas CIvil 2022]	1034.164	**mm**
Distance from the Neutral Axis to the Top Fiber	**: ya**	= [hg - yb]	1065.836	**mm**
Section Modulus of the Bottom Fiber	**: Sb**	= [Ig / yb]	4.252E+08	**mm^3**
Section Modulus of the Top Fiber	**: Sa**	= [Ig / ya]	4.125E+08	**mm^3**

2. Tensile Stress at Bottom Fiber at Combination of Service III (Calculation Result of Midas CIvil 2022)

Tensile Stress at Bottom Fiber	**: f_{bserv}**	= [Calculation Result of Midas CIvil 2022]	20.752	**MPa**

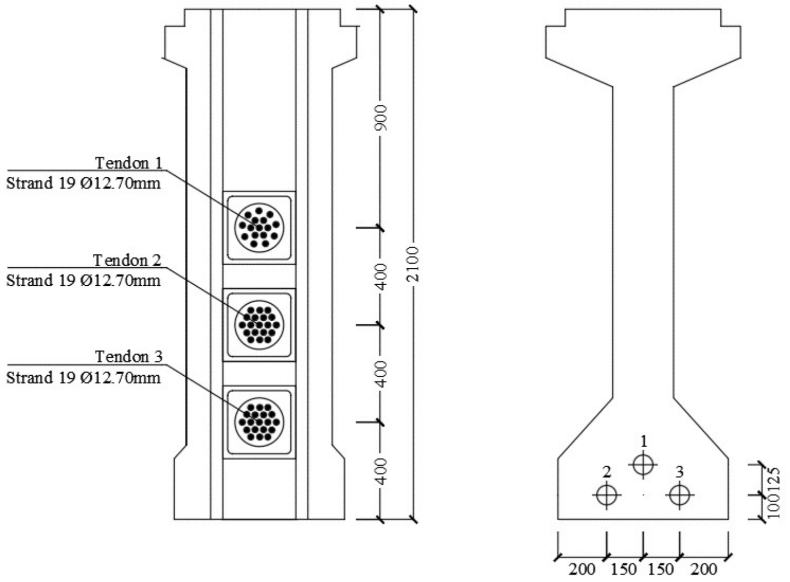
3. Calculating the Active Prestressed Force

Allowable Stress Under Service Load Conditions	**: $f_{allserv}$**	= [0.5 √ fc']	3.536	**MPa**
Tensile Stress Required at The Bottom Fiber	**: fpb**	= [fallserv - fbserv]	17.216	**MPa**
Distance From The Center of Prestress to The Bottom Fiber	**: ybs**	= [0.1 hg]	210	**mm**
Eccentricity at The Mid-Span	**: e_c**	= [yb - ybs]	824.164	**mm**
Active Prestressed Force	**: Pe**	= [(fpb*Ag*Sb) / (Sb + e_c *Ag]	5490.584	**kN**

4. Counting the Number of Strands

Loss of Pretension Force (T.Y Lin)	**: losses**		20	**%**
Final Prestressing Force per Strand	**: P_{e_strand}**	= [Aps.fpbt (1 - losses]	110.160	**kN**
Number of Strands Required	**: N_{str_req}**	= [Pe / Pe_strand]	50	**Strand**
Number of Strands Used	**: N_{str}**	≥ [Nstr_req]	57	**Strand**
Number of Tendon Used	**: N**	=	3	**Tendon**

5. Position of Tendon



Tendon Number	Tendon Code	Number of Strands	Tendon Position in the end of the pan (mm)		Tendon position in the middle of the Span(mm)		Distance of end position and Mid (mm)	
			Yi	Zi	Yj	Zj	ΔY	ΔZ
1	T1	19	0	1200	0	250	0	950
2	T2	19	0	800	150	100	-150	700
3	T3	19	0	400	-150	100	150	300

Inspection of Prestressed Concrete Designs Using Midas Civil 2022

Calculation of Bridge Superstructure Reinforcement

Reinforcement Calculation of Prestressed Girder (PCI-Girder)

1. Flexure Reinforcement of Edge PCI-Girder (Just Need Minimum Reinforcement)

Diameter of Rebar	: **Ds**	=	13	**mm**
Area of Rebar	: **As**	= [(1/4) π Ds^2]	132.732	**mm^2**
Cross-Sectional Area	: **A_g**	= [Midas Civil Calculation]	1320300	**mm^2**
Reinforcement Area Required	: **A_{s_req}**	= [0.4% A_g]	5281.200	**mm^2**
Number of Rebar Required	: **N**	= [A_{s_req} / As]	39.788	
Number of Rebar Used	:	**40D13**		

1. Flexure Reinforcement of Middle PCI-Girder (Just Need Minimum Reinforcement)

Diameter of Rebar	: **Ds**	=	13	**mm**
Area of Rebar	: **As**	= [(1/4) π Ds^2]	132.732	**mm^2**
Cross-Sectional Area	: **A_g**	= [Midas Civil Calculation]	825550	**mm^2**
Reinforcement Area	: **A_{s_req}**	= [0.4% A_g]	3302.200	**mm^2**
Number of Rebar Required	: **N**	= [A_{s_req} / As]	24.879	**buah**
Number of Rebar Used	:	**26D13**		

2. Shear Reinforcement of Prestressed Beam (Trial and Error in Midas Civil 2022)

Diameter of Rebar	: **D_v**	=	13	**mm**
Number of Rebar	: **n_v**	=	2	
Area of Shear Reinforcement	: **A_v**	= [(1/4) * π * d_v^2 * n_v]	265.465	**mm^2**
Specing of Field Reinforcement	:	**D13-200**		
Specing of Support Reinforcement	:	**D13-100**		

Reinforcement Calculation of Bridge Floor Slab

1. General Data of Floor Slabs				
Effective Width of Floor Slabs	**: b**	= [Initial Data]	2000	**mm**
Thickness of Floor Slab	**: ts**	= [Initial Data]	250.000	**mm**
Concrete Grade	**: fc'**	= [Initial Data]	30.000	**MPa**
Yield Strength of Rainforcement Steel (D ≥ 13)	**: fy**	= [Initial Data]	420	**MPa**
Yield Strength of Rainforcement Steel (D < 13)	**: fy**	= [Initial Data]	240	**MPa**
Concrete Cover	**: cd**	= [Input]	30	**mm**
2. Flexure Reinforcement of Floor Slab				
Diameter of Rebar	**: Df**	= [Input]	16	**mm**
Flexural Reduction Factor	**: ϕf**	=	0.9	
Momen Ultimate	**: Mu**	= [Midas Civil Calculation]	138.005	**kN.m**
Effective Thickness of the Floor Slab	**: de**	= [h - dc -0.5D]	212	**mm**
Concrete Stress Distribution Shape Factor	**: β_1**	= [fc' > 30 MPa]	0.85	
Reinforcement Ratio in Balance Condition	**: ρ_b**	= [β1* 0.85 * fc'/ fy * 600 / (600 + fy)]	0.03035714	**kN.m**
Maximum Moment Resistance Factor	**: Rnmax**	= [0.75*ρb*fy*(1–½*0.75*ρb*fy/(0.85*fc')]	7.76953125	**kN/m^2**
Nominal Moment (Planned Moment)	**: Mn**	= [Mu / ϕ]	153.339	**mm^2**
Moment Resistance Factor	**: Rn**	= [Mn * 10^6 / (b * de^2)]	1.706	**kN/m^2**
		Rn < Rnmax	**OK!**	
Required Reinforcement Ratios	**: ρ**	= [0.85*fc'/fy*(1-√[1 – 2 * Rn/(0.85*fc'))]	0.0042	
Minimum Reinforcement Ratio	**: ρ_{min}**	= [1.4 / fy]	0.0033	
Reinforcement Ratio Used	**: ρ**	= [min (ρ , ρ min)]	0.0042	
Required Reinforcement Area	**: As**	= [ρ * b * de]	1784	**mm^2**
Maximum Spacing of Flexure Reinforcement	**: Smax**	= [(1/4) * π * D^2 * b / As]	225	**mm**
Spacing of Flexure Reinforcement Used	**: S**	=	100	**mm**
Longitudinal Flexure Reinforcement Used	**:**	**D16 - 100**		
3. Transverse Reinforcement of Floor Slab				
Diameter of Rebar	**: Dv**	= [Input]	13	**mm**
Reinforcement Percentage	**: Pt**	= [Min (110/√S, 67%]	67	**%**
Minimum Area of Transverse Reinforcement	**: As_req**	= [(As_req * Pt)]	1195.245	**mm^2**
Maximum Spacing of Transverse Reinforcement	**: Smax**	= [(b * (1/4) * π * D^2)/ As_req]	222.101	**mm**
Spacing of Flexure Reinforcement Used	**: S**		100	**mm**
Specing of Transverse Reinforcement Used	**:**	**D13 - 100**		

Reinforcement Calculation of Bridge Diaphragm			
1. General Data of Diaphragm			
Height of Diaphragm	**: h**	= [Initial Data]	1280 **mm**
Thickness of Diaphragm	**: t**	= [Initial Data]	200
Concrete Grade	**: fc'**	= [Initial Data]	30 **MPa**
Yield Strength of Rainforcement Steel (D ≥ 13)	**: fy**	= [Initial Data]	420 **MPa**
Yield Strength of Rainforcement Steel (D < 13)	**: fy**	= [Initial Data]	240 **MPa**
Concrete Cover	**: dc**	= [Input]	30 **mm**
2. Flexure Reinforcement of Diaphragm			
Diameter of Rebar	**: Df**	= [Input]	13 **mm**
Flexural Reduction Factor	**: ϕf**	= [SNI 2847-2019]	0.90
Ultimate Moment	**: Mu**	= [Midas Civil Calculation]	4.56 **kN.m**
Effective Thickness of the Floor Slab	**: de**	= [t - dc -0.5Df]	163.5 **mm**
Concrete Stress Distribution Shape Factor	**: β_1**	= [fc' > 30 MPa]	0.85
Reinforcement Ratio in Balance Condition	**: ρ_b**	= [β1* 0.85 * fc'/ fy * 600 / (600 + fy)]	0.03035714 **kN.m**
Maximum Moment Resistance Factor	**: Rnmax**	= [0.75*ρb*fy*(1–½*0.75*ρb*fy/(0.85*fc')]	7.76953125 **kN/m²**
Nominal Moment (Planned Moment)	**: Mn**	= [Mu / ϕ]	5.067 **mm²**
Moment Resistance Factor	**: Rn**	= [Mn * 10^6 / (h * de^2)]	0.948 **kN/m²**
		Rn < Rnmax	OK!
Required Reinforcement Ratios	**: ρ**	= [0.85*fc'/fy*(1-√[1 – 2 * Rn/(0.85*fc'))]	0.0023
Minimum Reinforcement Ratio	**: ρ_{min}**	= [1.4 / fy]	0.0033
Reinforcement Ratio Used	**: ρ**	= [min (ρ , ρ min)]	0.0033
Required Reinforcement Area	**: As**	= [ρ * h * de]	698 **mm²**
Maximum Spacing of Flexure Reinforcement	**: Smax**	= [(1/4) * π * D^2 * h / As]	244 **mm**
Spacing of Flexure Reinforcement Used	**: S**		200 **mm**
Longitudinal Flexure Reinforcement Used	**:**	**D13 - 200**	
3. Shear Reinforcement of Diaphragm			
Diameter of Rebar	**: Dv**	= [Input]	10 **mm**
Shear Reduction Factor	**ϕv**	= [SNI 2847-2019]	0.75
Ultimate Shear Force	**: Vu**	= [Midas Civil Calculation]	11.693 **kN**
Effective Thickness of the Pilecap	**: de**	= [t- dc - Df - 0.5Dv]	152 **mm**
Concrete Shear Strength	**: Vc**	= [(1/6) √(f'c Mpa) de h]	191.045628 **mm2**
Smallest Factored Shear Force	**:**	= [0.5 ϕv Vc]	71.6421105
Check Concrete Shear Value	**: Vu < 0.5 ϕv Vc**		
	: No need for shear reinforcement, only need practical reinforcement		
Shear Reinforcement Used	**:**	**D10 - 200**	

Reinforcement Calculation of Deck Slab

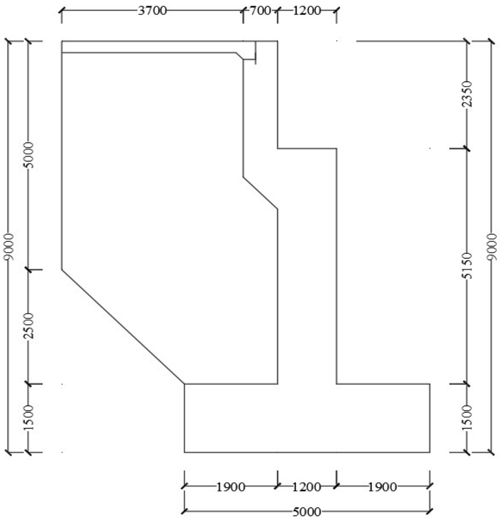
1. General Data of Deck Slab				
Effective Width of Deck Slabs	: **b**	= [Initial Data]	1360	**mm**
Thickness of Deck Slab	: **ts**	= [Initial Data]	70.000	**mm**
Concrete Grade	: **fc'**	= [Initial Data]	30.000	**MPa**
Yield Strength of Rainforcement Steel (D ≥ 13)	: **fy**	= [Initial Data]	420	**MPa**
Yield Strength of Rainforcement Steel (D < 13)	: **fy**	= [Initial Data]	240	**MPa**
Momen Ultimate	: **Mu**	= [Midas Civil Calculation]	0.39	**kN.m**
Flexural Reduction Factor	: **ϕf**		0.9	
Concrete Cover	: **cd**	= [Input]	30	**mm**
2. Flexure Reinforcement of Floor Slab				
Diameter of Rebar	: **Df**	= [Input]	10	**mm**
Effective Thickness of the Deck Slab	: **de**	**= [h - dc -0.5D]**	35	**mm**
Concrete Stress Distribution Shape Factor	: **β_1**	= [fc' > 30 MPa]	0.85	
Reinforcement Ratio in Balance Condition	: **ρ_b**	= [β1* 0.85 * fc'/ fy * 600 / (600 + fy)]	0.06450893	**kN.m**
Maximum Moment Resistance Factor	: **Rnmax**	= [0.75*ρb*fy*(1–½*0.75*ρb*fy/(0.85*fc')]	8.96789302	**kN/m^2**
Nominal Moment (Planned Moment)	: **Mn**	= [Mu / ϕ]	0.428	**mm^2**
Moment Resistance Factor	: **Rn**	= [Mn * 10^6 / (b * de^2)]	0.257	**kN/m^2**
		Rn < Rnmax	OK!	
Required Reinforcement Ratios	: **ρ**	= [0.85*fc'/fy*(1-√[1 – 2 * Rn/(0.85*fc'))]	0.0011	
Minimum Reinforcement Ratio	: **ρ_{min}**	= [1.4 / fy]	0.0058	
Reinforcement Ratio Used	: **ρ**	= [min (ρ , ρ min)]	0.0058	
Required Reinforcement Area	: **As**	= [ρ * b * de]	278	**mm^2**
Maximum Spacing of Flexure Reinforcement	: **Smax**	= [(1/4) * π * D^2 * b / As]	385	**mm**
Spacing of Flexure Reinforcement Used	: **S**		200	**mm**
Longitudinal Flexure Reinforcement Used	:	**D10 - 200**		
3. Transverse Reinforcement of Floor Slab				
Diameter of Rebar	: **Dv**	= [Input]	10	**mm**
Reinforcement Percentage	: **Pt**	= [Min (110/√S, 67%]	67	**%**
Minimum Area of Transverse Reinforcement	: **As_reqp**	= [(As_req * Pt)]	186.037	**mm^2**
Maximum Spacing of Transverse Reinforcement	: **Smax**	= [(b * (1/4) * π * D^2)/ As_req]	574.156	**mm**
Spacing of Flexure Reinforcement Used	: **S**		300	**mm**
Specing of Transverse Reinforcement Used	:	**D10 - 300**		

Preliminary Design of Substructure and Foundation

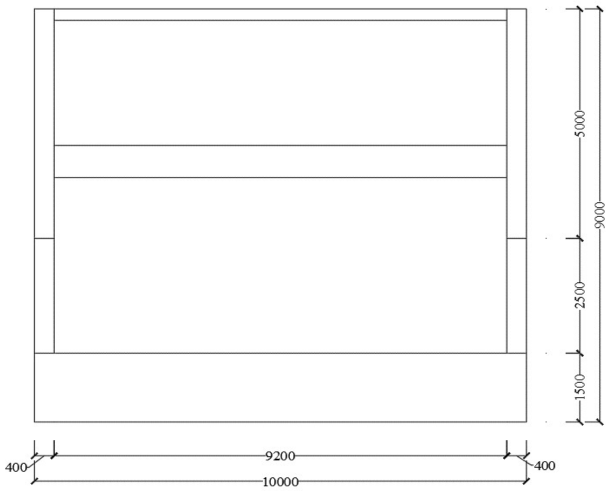
1. General Data of Substructure and Foundation

Hight of Abudment Required	**: Pu**	9 **m**
Types of Abutments Used	**: Reverse T-Type Abutment**	
Types of Foundations Used	**: Pile Foundation**	
Diamater of the Foundation	**: D**	0.80 **m**
Depth of Pile	**: H**	15 **m**
Number of Pile	**: n**	10 **Pieces**

2. Dimension of Bridge Substructure

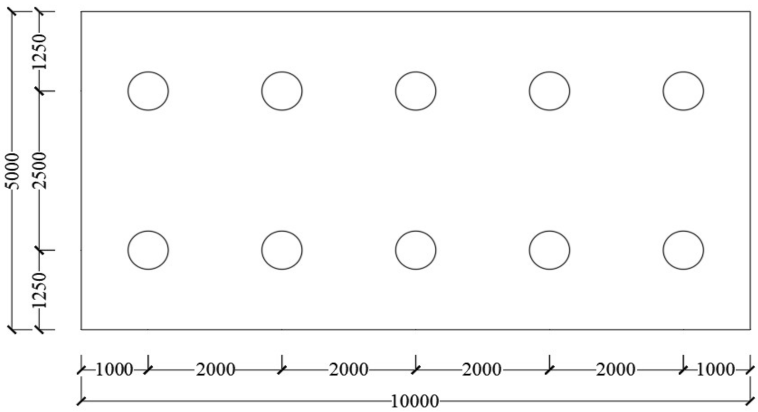


Side View of Substructure



Back View of Substructure

3. Dimension of Foundation



Loading of Bridge Substucture and Foundation

1. Loads from Superstructure Reaction				
Self-Weight of the Superstructure	**: MS**	= [Midas Civil Calculation]	721.560	**kN**
Berrier and Sidewalk Load	**: MA**	= [Midas Civil Calculation]	162.978	**kN**
Wearing Surface load	**:** $MA_{(uty)}$	= [Midas Civil Calculation]	38.733	**kN**
Pedestrian Load	**: TP**	= [Midas Civil Calculation]	48.854	**kN**
Line Load	**: TD**	= [Midas Civil Calculation]	432.668	**kN**
Truck Load	**: TT**	= [Midas Civil Calculation]	393.998	**kN**
2. Load due to Active Ground Pressure				
Specific Gravity of Soil	**: γsoil**		18	kN/m^3
Angle of Internal Friction	**: ϕ**		30	**MPa**
Cohesion of Soil	**: C**		1	kN/m^2
Active Earth Pressure Coefficient	**: Ka**	= [$Tan^2(45° - (\phi/2))$]	0.333	
Active Ground Pressure for Depth 0 m	**:** P_{A1}	= [(1/2) D * γ_{soil} * Ka]	0.000	**kN**
Active Ground Pressure for Depth 2.45 m	**:** P_{A2}	= [(1/2) D * γ_{soil} * Ka]	7.350	**kN**
Active Ground Pressure for Depth 6 m	**:** P_{A3}	= [(1/2) D * γ_{soil} * Ka]	18.000	**kN**
Active Ground Pressure for Depth 7.5 m	**:** P_{A4}	= [(1/2) D * γ_{soil} * Ka]	22.500	**kN**
3. Vertical Springs for the Soils Adjacent to Piles				
For Depths 0 - 6 m				
Soil Type	**:**		**Loose Sand**	
Diameter of Pile	**: D**		0.80	**m**
Unit Weight of Soil	**:** γ_{soil}		18.00	kN/m^3
Internal Friction Angle	**: ϕ**		32	°
Coeff. of Subgrade Reaction	**: Ko**	= [1- Sin(ϕ)]	0.47	
Coeff. of Subgrade Reaction	**: Kh**	= [Table 3.12 (Terzaghi).]	1.086	kN/m^3
For Depths 6 - 30 m				
Soil Type	**:**		**Dense Sand**	
Diameter of Pile	**: D**		0.80	**m**
Unit Weight of Soil	**:** γ_{soil}		22.00	kN/m^3
Internal Friction Angle	**: ϕ**		40	°
Coeff. of Subgrade Reaction	**: Ko**	= [1- Sin(ϕ)]	0.36	
Coeff. of Subgrade Reaction	**: Kh**	= [Table 3.12 (Terzaghi).]	10.857	kN/m^3

Bridge Substucture and Foundation Analysis with Midas Civil 2022

Stability of Abutment and Bearing Capacity of Foundation

Stability of Abutment

1. Control of Abutment Stability Againts Tipping (Rolling)

Vertical Moment	**: Mv**	= [Midas Civil Calculation]	699.099	**kN.m**
Horizontal Moment	**: Mh**	= [Midas Civil Calculation]	332.053	**kN.m**
Factor of Safety	**: SoF**		2	
Factor of Safety For Tipping	**: Soft**	= [Mv/Mh]	2.105	
Control		= [SoFt > SoF]	**OK!**	

2. Control of Abutment Stability Againts Shearing

Angle of Internal Friction	**: ϕ**	=	30	**°**
Cohesion of Soil	**: C**	=	1	**kN/m^2**
Area of Abutment Base	**: A**	= [P . L]	50	**m^2**
Vertical Force	**: V**	= [Midas Civil Calculation]	1595.589	**kN**
Horizontal Force	**: H**	= [Midas Civil Calculation]	325.934	**kN**
Factor of Safety	**: SoF**		1.5	
Factor of Safety For Shear	**: Sofx**	= [((C * A) + (V * tan ϕ)) / Hx]	2.97978652	
Control		= [SoFx > SoF]	**OK!**	

Bearing Capacity of Foundation

1. Soil Parameters

N-SPT for Depth 0 - 6 m	**: N_1**	= [Initial Data]	10	
N-SPT for Depth 6 - 15 m	**: N_2**	= [Initial Data]	50	
Soil Specific Gravity for Depth 0 - 6 m	**: γ_1**	= [Initial Data]	18	**kN/m^3**
Soil Specific Gravity for Depth 6 - 15 m	**: γ_2**	= [Initial Data]	22	**kN/m^3**
Safety of Factor	**: SoF**	= [Initial Data]	2.5	
Length of Pile	**: H**	= [Preliminary Design]	15	**m**
Pile Length at Depth 0 - 6 m	**: H_1**	= [Preliminary Design]	6	**m**
Pile Length at Depth 6 - 15 m	**: H_2**	= [Preliminary Design]	9	**m**
Diameter of Pile	**: D**	= [Preliminary Design]	0.8	**m**
Lateral Surface Area for Depth 0 - 6 m	**: A_{S1}**	= [π * D * H_1]	15.080	**mm^2**
Lateral Surface Area for Depth 6 - 15 m	**: A_{S2}**	= [π * D * H_2]	22.619	**mm^2**
Pile Area Tip	**: At**	= [(1/4) * π * D^2]	0.503	**mm^2**

1. Foundation Data

Length of Pile	**: f_{S1}**	= [2 * N_1 < 100 kPa]	20	**kPa**
Pile Length at Depth 0 - 6 m	**: f_{S2}**	= [2 * N_2 < 100 kPa]	100	**kPa**
Pile Length at Depth 6 - 15 m	**: qt**	= [(40 * N2 kPA * H) / D]	10000	**kPa**
Ultimate Skin Friction at Depth 0 - 6 m	**: R_{S1}**	= [f_{S1} *A_{S1}]	301.593	**kN**
Ultimate Skin Friction at Depth 6 - 15 m	**: R_{S2}**	= [f_{S2} *A_{S2}]	2261.947	**kN**
Ultimate End Bearing	**: Rt**	= [qt * At]	5026.548	**kN**
Ultimate Pile Capacity	**: Qu**	= [R_{S1} + R_{S2} + Rt]	7590.088	**kN**
Allowable Load	**: Qa**	= [Qu / SoF]	3036.035	**kN**
Structure Axial Load	**: Pu**	=	1886.38	**kN**
Control	**:**	**Qa > Pu**	**OK**	

Calculation of Bridge Substructure Reinforcement

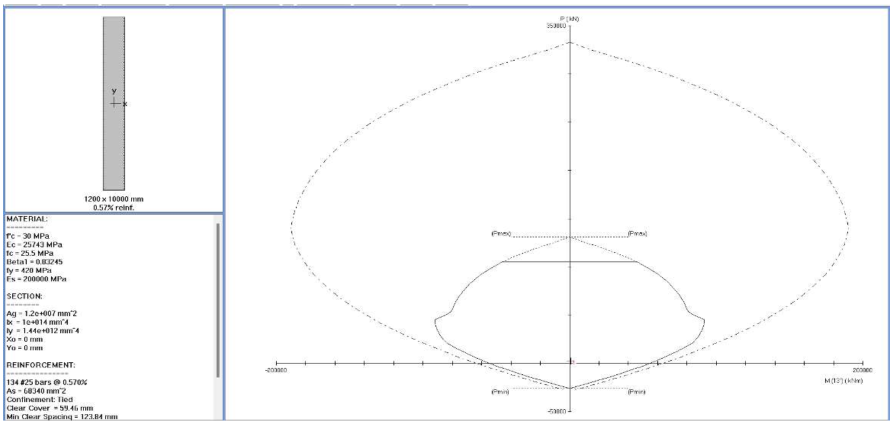
Reinforcement Calculation of Breastwall

1. General Data of Breastwall

Height of Breastwall	**: h**	= [Initial Data]	1200 **mm**
Longitudinal Width of Breastwall	**: bx**	= [Initial Data]	10000 **mm**
Transversal Width of Breastwall	**: by**	= [Initial Data]	5050 **mm**
Concrete Grade	**: fc'**	= [Initial Data]	30 **MPa**
Yield Strength of Reinforcement Steel (D ≥ 13)	**: fy**	= [Initial Data]	420 **MPa**
Yield Strength of Reinforcement Steel (D < 13)	**: fy**	= [Initial Data]	240 **MPa**
Concrete Cover	**: dc**	= [Input]	50 **mm**

2. Axial - Flexure Reinforcement

Diameter of Flexure Rebar	**: Db**	= [Input]	25 **mm**
Ultimate Moment	**Mux**	= [Midas Civil Calculation]	699.099 **kN.m**
Ultimate Moment	**Muy**	= [Midas Civil Calculation]	332.053 **kN.m**
Ultimate Axial Force	**Pu**	= [Midas Civil Calculation]	1595.589 **kN**
Spacing of Rebar	**: S**	= [Input]	150 **mm**
Number of Reinforcement	**: n**	= [bx / s]	67
Reinforcement Area	**: As**	= [n * (1/4) * π *Db^2]	65777.096 **mm^2**
Cross-Sectional Area	**: Ag**	= [bx * by]	12000000 **mm^2**
Reinforcement Ratios	**: ρ**	= [As / Ag]	0.548 **%**
Minimum Reinforcement Ratio	**: ρ_{min}**		0.500 **%**
Check Minimum Reinforcement Ratio		$\rho_{min} > \rho$	**OK**
Axial-Flexure Reinforcement Used	**:**	**D 25 - 150**	



The combination of Pu and Mu loads in the interaction diagram indicates that the Breastwall section can carry the loads that occur. The interaction diagram above is an interaction diagram of the abutment cross section using the main reinforcement D25 - 150

3. Transverse Reinforcement

Diameter of Flexure Rebar	: D	= [Input]	16	mm
Concrete Density Modification Factors	: λ	=	1	
Indication Factor	: β	=	2	
Reduction Factor	: ϕv	= [SNI 2847-2019]	0.75	
Ultimate Shear Force	: Vu	= [Midas Civil Calculation]	316.681	kN.m
Evaluated Over a 1-Meter Distance	: b'	=	1000	mm
Effective Thickness of the Breastwall	: de	= [h - dc -0.5D]	1142	mm
Concrete Shear Strength	: Vc	= [0.083 * β * √(f'c Mpa) *b *de]	10383.2861	kN
	:	= [0.5 ϕv Vc]	3893.73228	
Check Concrete Shear Value	: Vu < 0.5 ϕv Vc			
	: Use Minimum Shear Reinforcement			
Minimum Shear Reinforcement Area	: Av_min	= [(0.083*λ*√(f'c Mpa)*b*b') / fy]	10824.041	mm^2
Attempted Reinforcement Distance	: S		150	mm
Reinforcement Area Used	: Av_use	= [(1/4) * π * D^2 * b / S]	13404.1287	mm^2
Control Reinforcement Area	:	Av_use > Av_min	OK!	
Shear Reinforcement Used	:	D16 - 150		

4. Shear Reinforcement

Diameter of Flexure Rebar	: D	= [Input]	16	mm
Concrete Density Modification Factors	: λ	=	1	
Indication Factor	: β	=	2	
Reduction Factor	: ϕv	= [SNI 2847-2019]	0.75	
Ultimate Shear Force	: Vu	= [Midas Civil Calculation]	316.681	kN.m
Evaluated Over a 1-Meter Distance	: b'	=	1000	mm
Effective Thickness of the Breastwall	: de	= [h - dc -0.5D]	1142	mm
Concrete Shear Strength	: Vc	= [0.083 * β * √(f'c Mpa) *b *de]	5191.64303	mm2
Smallest Factored Shear Force	:	= [0.5 * ϕv * Vc]	1946.86614	
Check Concrete Shear Value	: Vu < 0.5 * ϕv * Vc			
	: Use Minimum Shear Reinforcement			
Spasing of Shear Reinforcement Y Direction Used	: Sy		600	mm
Shear Reinforcement Strength	: Vs	= [(Vu / ϕv) - Vc]	-4769.4017	kN
Shear Reinforcement Area Required	: Av_1	= [(Vs * b) / (fy * de)]	-99437.113	mm^2
Minimum Shear Reinforcement Area	: Av_min	= [(0.083*λ*√(f'c Mpa)*b*b') / fy]	10824.041	mm^2
Shear Reinforcement Area Used	: Av	= [Max (Av_1, Av_min)]	10824.041	mm^2
Maximum Spacing od Shear Reinforcement	: Sx_max	= [(b*s*(1/4)*π*D^2) / (Av*Sy)]	309.591599	mm
Spasing of Shear Reinforcement X Direction Used	: Sx		300	mm
Shear Reinforcement Used	:	D16 - 300/600		

Reinforcement Calculation of Backwall				
1. General Data of Backwall				
Height of Backwall	: h	= [Initial Data]	700	mm
Longitudinal Width of Backwall	: bx	= [Initial Data]	10000	mm
Transversal Width of Backwall	: by	= [Initial Data]	2400	mm
Concrete Grade	: fc'	= [Initial Data]	30	MPa
Yield Strength of Rainforcement Steel (D ≥ 13)	: fy	= [Initial Data]	420	MPa
Concrete Cover	: dc	= [Input]	50	mm
2. Lingitudinal Flexure Reinforcement				
Diameter of Flexure Rebar	: D	= [Input]	19	mm
Flexure Reduction Factor	: ϕ_f	= [SNI 2847-2019]	0.9	
Ultmate Moment	: Mu	= [Midas Civil Calculation]	360.989	kN.m
Evaluated Over a 1-Meter Distance	: b'	=	1000	mm
Effective Thickness of the Backwall	: de	= [h - dc -0.5D]	640.5	mm
Concrete Stress Distribution Shape Factor	: β_1	= [fc' > 30 MPa]	0.85	
Reinforcement Ratio in Balance Condition	: ρ_b	= [β1* 0.85 * fc'/ fy * 600 / (600 + fy)]	0.03035714	
Maximum Moment Resistance Factor	: Rnmax	= [0.75*ρb*fy*(1–½*0.75*ρb*fy/(0.85*fc')]	7.76953125	kN/m^2
Nominal Moment (Planned Moment)	: Mn	= [Mu / ϕ]	401.099	kN.m
Moment Resistance Factor	: Rn	= [Mn * 10^6 / (b' * de^2)]	0.978	kN/m^2
		Rn < Rnmax	OK!	
Required Reinforcement Ratios	: ρ	= [0.85*fc'/fy*(1-√[1 – 2 * Rn/(0.85*fc'))]	0.0024	
Minimum Reinforcement Ratio	: ρ_{min}	= [0.5 / fy]	0.0012	
Reinforcement Ratio Used	: ρ	= [min (ρ , ρ min)]	0.0024	
Required Reinforcement Area	: As	= [ρ * b' * de]	1521	mm^2
Maximum Spacing of Flexure Reinforcement	: Smax	= [(1/4) * π * D^2 * b' / As]	186	mm
Spacing of Flexure Reinforcement Used	: S	v	150	mm
Longitudinal Flexure Reinforcement Used	:	**D19 - 150**		
3. Transverse Flexure Reinforcement				
Diameter of Flexure Rebar	: D	= [Input]	13	mm
Required Reinforcement Area	: As'	= [50% * As]	760	mm^2
Maximum Spacing of Flexure Reinforcement	: S'max	= [(1/4) * π * D^2 * b / As]	175	mm
Spacing of Flexure Reinforcement Used	: S'		150	mm
Longitudinal Flexure Reinforcement Used	:	**D13 - 150**		
4. Shear Reinforcement				
Diameter of Flexure Rebar	: Dv	= [Initial Data]	13	mm
Concrete Density Modification Factors	: λ		1	
Shear Reduction Factor	: ϕv	= [SNI 2847-2019]	0.75	
Ultimate Shear Force	: Vu	= [Midas Civil Calculation]	241.336	kN
Evaluated Over a 1-Meter Distance	: b'	=	1000	mm
Effective Thickness of the Backwall	: de	= [h - dc - 0.5Dv]	643.5	mm
Concrete Shear Strength	: Vc	= [(1/6) √(f'c Mpa) de b]	5874.32443	kN
Smallest Factored Shear Force	:	= [0.5 ϕv Vc]	2202.87166	kN
Check Concrete Shear Value	: Vu < 0.5 ϕv Vc			
	: Use Minimum Shear Reinforcement			
Spasing of Shear Reinforcement Y Direction Used	: Sy	=	400	mm
Shear Reinforcement Strength	: Vs	= [(Vu / ϕv) - Vc]	-5552.5431	kN
Shear Reinforcement Area Required	: Av_1	= [(Vs * b) / (fy * de)]	-205444.3	mm^2
Minimum Shear Reinforcement Area	: Av_min	= [(0.083*λ*√(f'c Mpa)*b*b') / fy]	10824.041	mm^2
Shear Reinforcement Area Used	: Av	= [Max (Av_1, Av_min)]	10824.041	mm^2
Maximum Spacing od Shear Reinforcement	: Sx_max	= [(b*b'*(1/4)*π*D^2) / (Av*Sy)]	306.568243	mm
Spasing of Shear Reinforcement X Direction Used	: Sx	=	300	mm
Shear Reinforcement Used	:	**D13 - 300/400**		

Reinforcement Calculation of Wingwall

1. General Data of Wingwall			
Height of Wingwall	**: h**	= [Initial Data]	400 **mm**
Longitudinal Width of Wingwall	**: bx**	= [Initial Data]	7500 **mm**
Transversal Width of Wingwall	**: by**	= [Initial Data]	4400 **mm**
Concrete Grade	**: fc'**	= [Initial Data]	30 **MPa**
Yield Strength of Reinforcement Steel (D ≥ 13)	**: fy**	= [Initial Data]	420 **MPa**
Yield Strength of Reinforcement Steel (D < 13)	**: fy**	= [Initial Data]	240 **MPa**
Concrete Cover	**: dc**	= [Input]	50 **mm**
2. Longitudinal Flexure Reinforcement			
Diameter of Flexure Rebar	**: D**	= [Input]	16 **mm**
Flexure Reduction Factor	**: ϕ_f**	= [SNI 2847-2019]	0.9
Ultmate Moment	**: Mu**	= [Midas Civil Calculation]	132.427 **kN.m**
Evaluated Over a 1-Meter Distance	**: b'**	=	1000 **mm**
Effective Thickness of the Wingwall	**: de**	= [h - dc -0.5D]	342 **mm**
Concrete Stress Distribution Shape Factor	**: β_1**	= [fc' > 30 MPa]	0.85
Reinforcement Ratio in Balance Condition	**: ρ_b**	= [β1* 0.85 * fc'/ fy * 600 / (600 + fy)]	0.03035714
Maximum Moment Resistance Factor	**: Rnmax**	= [0.75*ρb*fy*(1–½*0.75*ρb*fy/(0.85*fc')]	7.76953125 **kN/m^2**
Nominal Moment (Planned Moment)	**: Mn**	= [Mu / ϕ]	147.141 **kN.m**
Moment Resistance Factor	**: Rn**	= [Mn * 10^6 / (b' * de^2)]	1.258 **kN/m^2**
		Rn < Rnmax	OK!
Required Reinforcement Ratios	**: ρ**	= [0.85*fc'/fy*(1-√[1 – 2 * Rn/(0.85*fc'))]	0.0031
Minimum Reinforcement Ratio	**: ρ_{min}**	= [0.5 / fy]	0.0012
Reinforcement Ratio Used	**: ρ**	= [min (ρ , ρ min)]	0.0031
Required Reinforcement Area	**: As**	= [ρ * b' * de]	1051 **mm^2**
Maximum Spacing of Flexure Reinforcement	**: Smax**	= [(1/4) * π * D^2 * b' / As]	191 **mm**
Spacing of Flexure Reinforcement Used	**: S**		150 **mm**
Longitudinal Flexure Reinforcement Used	**:**	**D16 - 150**	
3. Transverse Flexure Reinforcement			
Diameter of Flexure Rebar	**: D**	= [Input]	13 **mm**
Required Reinforcement Area	**: As'**	= [50% ∗ As]	525 **mm^2**
Maximum Spacing of Flexure Reinforcement	**: S'max**	= [(1/4) * π * D^2 * b / As]	253 **mm**
Spacing of Flexure Reinforcement Used	**: S'**		150 **mm**
Longitudinal Flexure Reinforcement Used	**:**	**D13 - 150**	
4. Shear Reinforcement			
Diameter of Flexure Rebar	**: Dv**	= [Input]	13 **mm**
Concrete Density Modification Factors	**: λ**	=	1
Shear Reduction Factor	**: ϕv**	= [SNI 2847-2019]	0.75
Ultimate Shear Force	**: Vu**	= [Midas Civil Calculation]	110.527 **kN**
Evaluated Over a 1-Meter Distance	**: b'**	=	1000 **mm**
Effective Thickness of the Wingwall	**: de**	= [h - dc - 0.5Dv]	343.5 **mm**
Concrete Shear Strength	**: Vc**	= [(1/6) √(f'c Mpa) de b]	2351.78373 **kN**
Smallest Factored Shear Force	**:**	= [0.5 ϕv Vc]	881.918899 **kN**
Check Concrete Shear Value	**: Vu < 0.5 ϕv Vc**		
	: Use Minimum Shear Reinforcement		
Spasing of Shear Reinforcement Y Direction Used	**: Sy**	=	400 **mm**
Shear Reinforcement Strength	**: Vs**	= [(Vu / ϕv) - Vc]	-2204.4144 **kN**
Shear Reinforcement Area Required	**: Av_1**	= [(Vs * b) / (fy * de)]	-114598.38 **mm^2**
Minimum Shear Reinforcement Area	**: Av_min**	= [(0.083*λ*√(f'c Mpa)*b*b') / fy]	897.261586 **mm^2**
Shear Reinforcement Area Used	**: Av**	= [Max (Av_1, Av_min)]	897.261586 **mm^2**
Maximum Spacing of Shear Reinforcement	**: Sx_max**	= [(b*b'*(1/4)*π*D^2) / (Av*Sy)]	306.568243 **mm**
Spasing of Shear Reinforcement X Direction Used	**: Sx**	=	300 **mm**
Shear Reinforcement Used	**:**	**D13 - 300/400**	

Reinforcement Calculation of Approch Slab			
1. General Data of Approch Slab			
Height of Approch Slab	**: h**	= [Initial Data]	300 **mm**
Longitudinal Width of Approch Slab	**: bx**	= [Initial Data]	10000 **mm**
Transversal Width of Approch Slab	**: by**	= [Initial Data]	3700 **mm**
Concrete Grade	**: fc'**	= [Initial Data]	30 **MPa**
Yield Strength of Reinforcement Steel (D ≥ 13)	**: fy**	= [Initial Data]	420 **MPa**
Yield Strength of Reinforcement Steel (D < 13)	**: fy**	= [Initial Data]	240 **MPa**
Concrete Cover	**: dc**	= [Input]	50 **mm**
2. Lingitudinal Flexure Reinforcement			
Diameter of Flexure Rebar	**: D**	= [Input]	16 **mm**
Flexure Reduction Factor	**:** ϕ_f	= [SNI 2847-2019]	0.9
Ultmate Moment	**: Mu**	= [Midas Civil Calculation]	79.311 **kN.m**
Evaluated Over a 1-Meter Distance	**: b'**	=	1000 **mm**
Effective Thickness of the Approch Slab	**: de**	= [h - dc -0.5D]	242 **mm**
Concrete Stress Distribution Shape Factor	**:** β_1	= [fc' > 30 MPa]	0.85
Reinforcement Ratio in Balance Condition	**:** ρ_b	= [β1* 0.85 * fc'/ fy * 600 / (600 + fy)]	0.03035714
Maximum Moment Resistance Factor	**: Rnmax**	= [0.75*ρb*fy*(1–½*0.75*ρb*fy/(0.85*fc')]	7.76953125 **kN/m²**
Nominal Moment (Planned Moment)	**: Mn**	= [Mu / ϕ]	88.123 **kN.m**
Moment Resistance Factor	**: Rn**	= [Mn * 10^6 / (b' * de^2)]	1.505 **kN/m²**
		Rn < Rnmax	OK!
Required Reinforcement Ratios	**: ρ**	= [0.85*fc'/fy*(1-√(1 – 2 * Rn/(0.85*fc'))]	0.0037
Minimum Reinforcement Ratio	**:** ρ_{min}	= [1.4 / fy]	0.0033
Reinforcement Ratio Used	**: ρ**	= [min (ρ , ρ min)]	0.0037
Required Reinforcement Area	**: As**	= [ρ * b' * de]	894 **mm²**
Maximum Spacing of Flexure Reinforcement	**: Smax**	= [(1/4) * π * D^2 * b' / As]	225 **mm**
Spacing of Flexure Reinforcement Used	**: S**		200 **mm**
Longitudinal Flexure Reinforcement Used	**:**	**D16 - 200**	
3. Transverse Flexure Reinforcement			
Diameter of Flexure Rebar	**: D**	= [Input]	13 **mm**
Required Reinforcement Area	**: As'**	= [50% * As]	447 **mm²**
Maximum Spacing of Flexure Reinforcement	**: S'max**	= [(1/4) * π * D^2 * b / As]	297 **mm**
Spacing of Flexure Reinforcement Used	**: S'**		200 **mm**
Longitudinal Flexure Reinforcement Used	**:**	**D13 - 200**	
4. Shear Reinforcement			
Diameter of Flexure Rebar	**: Dv**	= [Input]	13 **mm**
Concrete Density Modification Factors	**: λ**	=	1
Shear Reduction Factor	**: ϕv**	= [SNI 2847-2019]	0.75
Ultimate Shear Force	**: Vu**	= [Midas Civil Calculation]	61.36 **kN**
Evaluated Over a 1-Meter Distance	**: b'**	=	1000 **mm**
Effective Thickness of the Approch Slab	**: de**	= [h - dc - 0.5Dv]	243.5 **mm**
Ultimate Shear Force	**: Vu**	= [Midas Civil Calculation]	61.36 **kN**
Concrete Shear Strength	**: Vc**	= [(1/6) √(f'c Mpa) de b]	2222.84071 **kN**
Smallest Factored Shear Force	**:**	= [0.5 ϕv Vc]	833.565267 **kN**
Check Concrete Shear Value	**: Vu < 0.5 ϕv Vc**		
	: Use Minimum Shear Reinforcement		
Spasing of Shear Reinforcement Y Direction Used	**: Sy**	=	400 **mm**
Shear Reinforcement Strength	**: Vs**	= [(Vu / ϕv) - Vc]	-2141.0274 **kN**
Shear Reinforcement Area Required	**:** Av_1	= [(Vs * b) / (fy * de)]	-209350.48 **mm²**
Minimum Shear Reinforcement Area	**: Av_min**	= [(0.083*λ*√(f'c Mpa)*b*b') / fy]	10824.041 **mm²**
Shear Reinforcement Area Used	**: Av**	= [Max (Av_1, Av_min)]	10824.041 **mm²**
Maximum Spacing of Shear Reinforcement	**: Sx_max**	= [(b*b'*(1/4)*π*D^2) / (Av*Sy)]	306.568243 **mm**
Spasing of Shear Reinforcement X Direction Used	**: Sx**	=	300 **mm**
Shear Reinforcement Used	**:**	**D13 - 300/400**	

Reinforcement Calculation of Pilecap

1. General Data of Pilecap

Height of Pilecap	: h	= [Initial Data]	1500 mm
Longitudinal Width of Pilecap	: bx	= [Initial Data]	10000 mm
Transversal Width of Pilecap	: by	= [Initial Data]	5000 mm
Concrete Grade	: fc'	= [Initial Data]	30 MPa
Yield Strength of Reinforcement Steel (D ≥ 13)	: fy	= [Initial Data]	420 MPa
Yield Strength of Reinforcement Steel (D < 13)	: fy	= [Initial Data]	240 MPa
Concrete Cover	: dc	= [Input]	50 mm

2. Longitudinal Flexure Reinforcement

Diameter of Flexure Rebar	: D	= [Input]	25 mm
Flexure Reduction Factor	: ϕ_f	= [SNI 2847-2019]	0.9
Ultmate Moment	: Mu	= [Midas Civil Calculation]	332.427 kN.m
Evaluated Over a 1-Meter Distance	: b'	=	1000 mm
Effective Thickness of the Pilecap	: de	= [h - dc -0.5D]	1437.5 mm
Concrete Stress Distribution Shape Factor	: β_1	= [fc' > 30 MPa]	0.85
Reinforcement Ratio in Balance Condition	: ρ_b	= [β1* 0.85 * fc'/ fy * 600 / (600 + fy)]	0.03035714
Maximum Moment Resistance Factor	: Rnmax	= [0.75*ρb*fy*(1–½*0.75*ρb*fy/(0.85*fc')]	7.76953125 kN/m^2
Nominal Moment (Planned Moment)	: Mn	= [Mu / ϕ]	369.363 kN.m
Moment Resistance Factor	: Rn	= [Mn * 10^6 / (b' * de^2)]	0.179 kN/m^2
		Rn < Rnmax	OK!
Required Reinforcement Ratios	: ρ	= [0.85*fc'/fy*(1-√[1 – 2 * Rn/(0.85*fc'))]	0.0004
Minimum Reinforcement Ratio	: ρ_{min}	= [0.5 / fy]	0.0012
Reinforcement Ratio Used	: ρ	= [min (ρ , ρ min)]	0.0012
Required Reinforcement Area	: As	= [ρ * b' * de]	1711 mm^2
Maximum Spacing of Flexure Reinforcement	: Smax	= [(1/4) * π * D^2 * b' / As]	287 mm
Spacing of Flexure Reinforcement Used	: S	=	150 mm
Longitudinal Flexure Reinforcement Used	:	**D25 - 150**	

3. Transverse Flexure Reinforcement

Diameter of Flexure Rebar	: D	= [Input]	19 mm
Required Reinforcement Area	: As'	= [50% * As]	856 mm^2
Maximum Spacing of Flexure Reinforcement	: S'max	= [(1/4) * π * D^2 * b / As]	331 mm
Spacing of Flexure Reinforcement Used	: S'	=	150 mm
Longitudinal Flexure Reinforcement Used	:	**D19 - 150**	

4. Shear Reinforcement

Diameter of Flexure Rebar	: Dv	= [Input]	16 mm
Concrete Density Modification Factors	: λ		1
Shear Reduction Factor	: ϕv	= [SNI 2847-2019]	0.75
Ultimate Shear Force	: Vu	= [Midas Civil Calculation]	110.527 kN
Effective Thickness of the Pilecap	: de	= [h - dc - 0.5Dv]	1442 mm
Evaluated Over a 1-Meter Distance	: b''	=	1000 mm
Concrete Shear Strength	: Vc	= [(1/6) √(f'c Mpa) b de]	13163.5988 kN
Smallest Factored Shear Force	:	= [0.5 ϕv Vc]	4936.34955 kN
Check Concrete Shear Value	: **Vu < 0.5 ϕv Vc**		
	: **Use Minimum Shear Reinforcement**		
Spasing of Shear Reinforcement Y Direction Used	: Sy	=	600 mm
Shear Reinforcement Strength	: Vs	= [(Vu / ϕv) - Vc]	-13016.229 kN
Shear Reinforcement Area Required	: Av_1	= [(Vs * b) / (fy * de)]	-214916.94 mm^2
Minimum Shear Reinforcement Area	: Av_min	= [(0.083*λ*√(f'c Mpa)*b*b') / fy]	10824.041 mm^2
Shear Reinforcement Area Used	: Av	= [Max (Av_1, Av_min)]	10824.041 mm^2
Maximum Spacing of Shear Reinforcement	: Sx_max	= [(b*b'*(1/4)*π*D^2) / (Av*Sy)]	309.591599 mm
Spasing of Shear Reinforcement X Direction Used	: Sx	=	300 mm
Shear Reinforcement Used	:	**D16 - 300/600**	

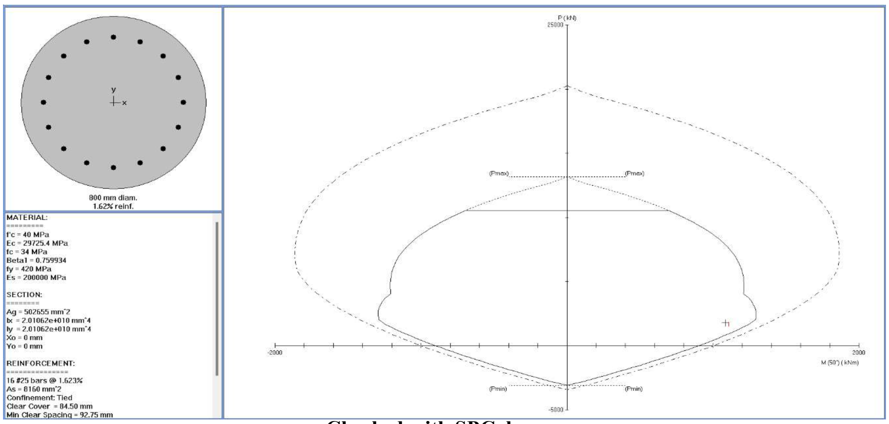
Reinforcement Calculation of Pile

1. General Data of Pilecap

Diamater of Pile	**: D**	= [Initial Data]	800 **mm**
Concrete Grade	**: fc'**	= [Initial Data]	30 **MPa**
Yield Strength of Rainforcement Steel (D ≥ 13)	**: fy**	= [Initial Data]	420 **MPa**
Yield Strength of Rainforcement Steel (D < 13)	**: fy**	= [Initial Data]	240 **MPa**
Concrete Cover	**: dc**	= [Input]	75 **mm**

2. Axial-Flexure Reinforcement

Diameter of Flexure Rebar	**: Db**	= [Input]	25 **mm**
Ultimate Moment for X Direction	**: Mux**	= [Midas Civil Calculation]	714.75 **kN.m**
Ultimate Moment for Y Direction	**: Muy**	= [Midas Civil Calculation]	857.36 **kN.m**
Ultimate Axial Force	**Pu**	= [Midas Civil Calculation]	1233.24
Number of Rebar	**: n**	= [Input]	16
Reinforcement Area	**: As**	= [n * (1/4) * π *Db^2]	7853.982 **mm**
Cross-Sectional Area	**: Ag**	= [(1/4) * π * D^2]	502654.825
Reinforcement Ratios	**: ρ**	= [Aσ/Aγ]	1.563
Minimum Reinforcement Ratio	**: ρ_{min}**	=	0.500 **%**
Check Minimum Reinforcement Ratio		$\rho_{min} > \rho$	**OK**
Axial-Flexure Reinforcement Used	**:**	**16D25**	

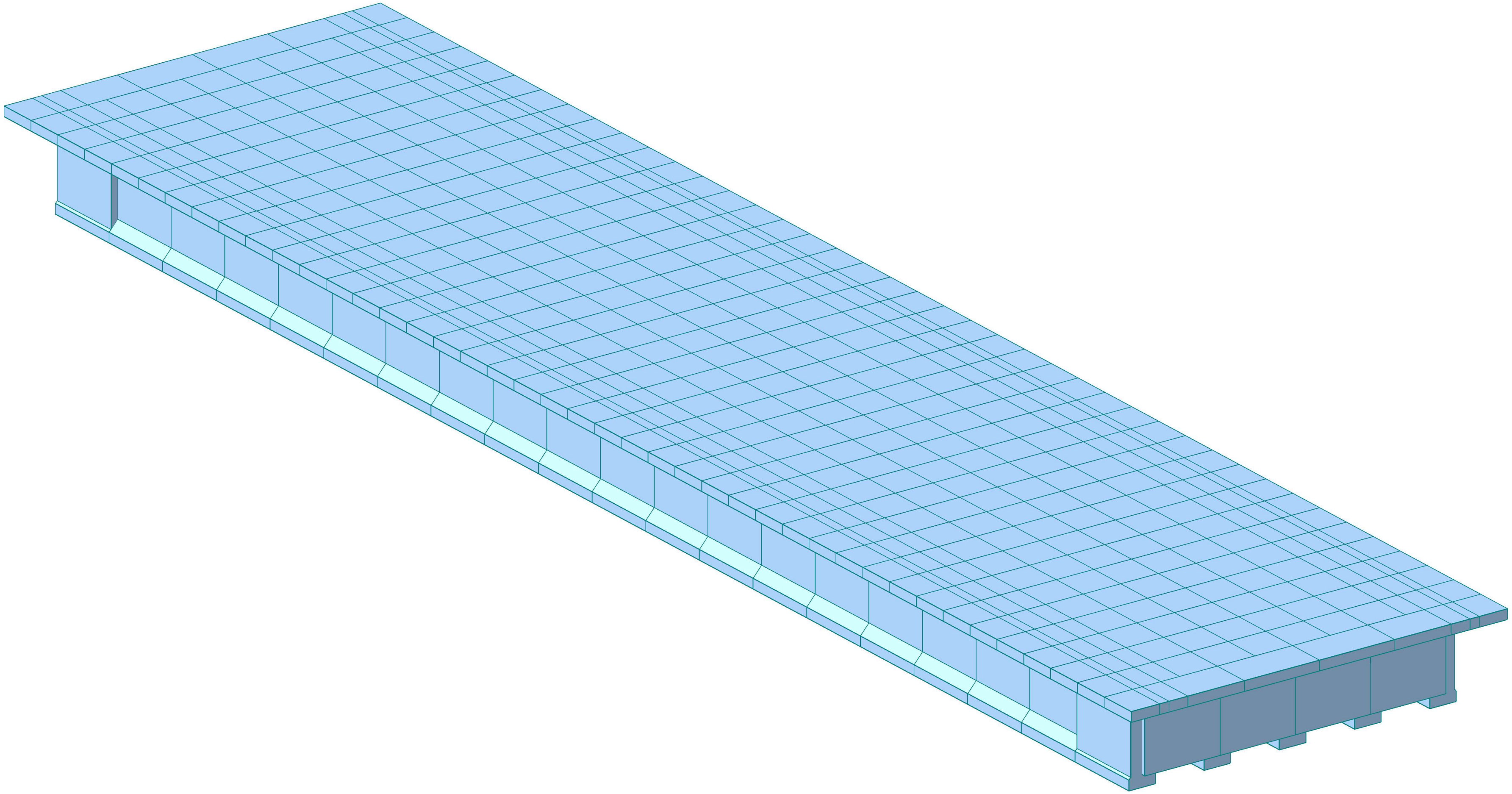


Checked with SPColumn

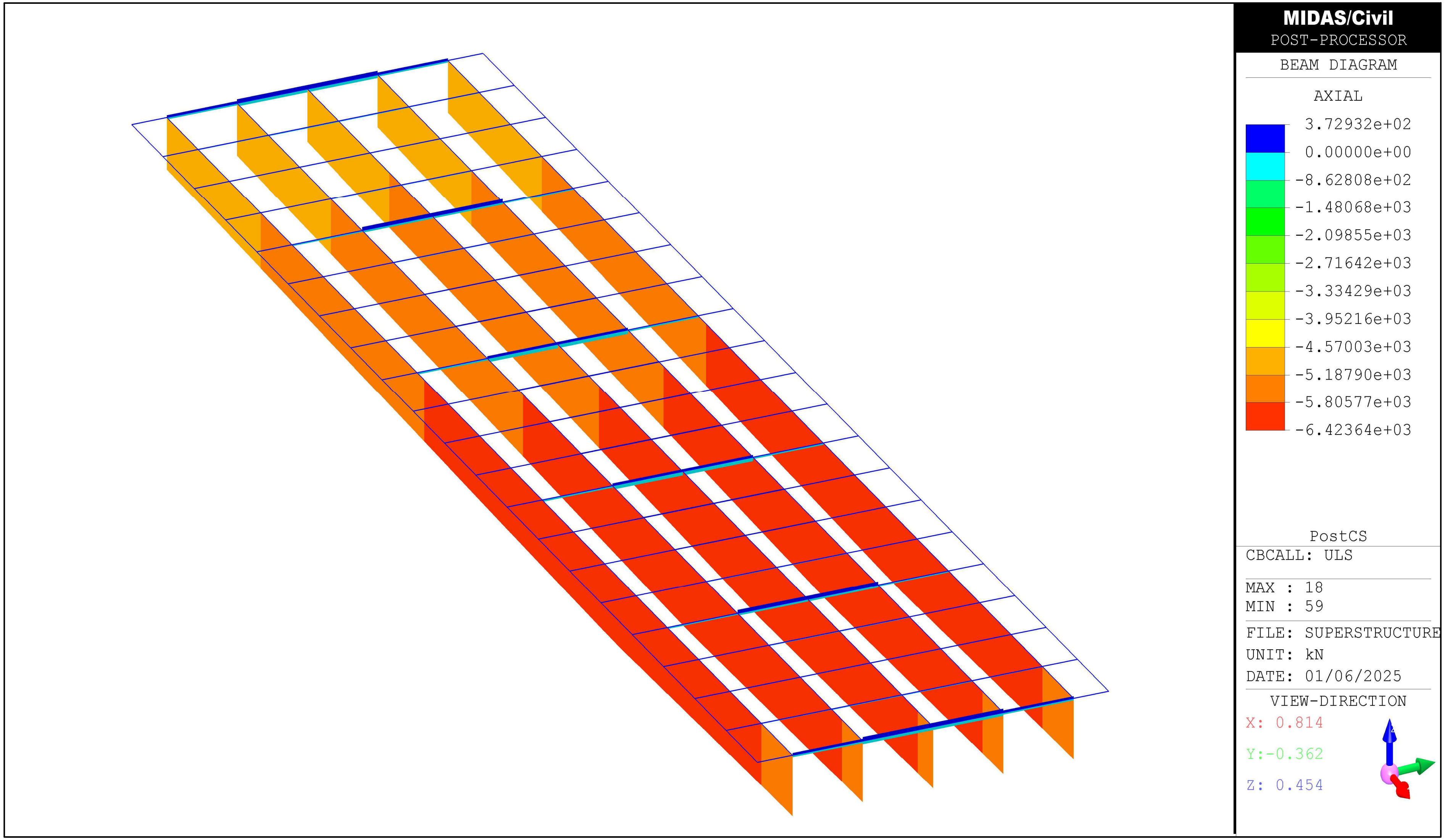
3. Shear Reinforcement

Diameter of Shear Rebar	**: Dv**	= [Input]	16 **mm**
Shear Reduction Factor	**: ϕv**	= [SNI 2847-2019]	0.75
Ultimate Shear Force	**: Vu**	= [Calculation Result of Midas CIvil 2022]	574.68 **kN**
Shear Reduction Factor	**: ϕv**	= [SNI 2847-2019]	0.75
Spacing of Shear Reinforcement	**: b'**	= [Input]	100 **mm^2**
Effective Height	**: de**	= [D - dc - Df - Dv/2]	692
Shear Reinforcement Area	**: Av**	= [2 * (1/4) * π * Dv^2]	201.062 **mm**
Concrete Shear Strength	**: Vc**	= [0.17*(1+Pu/(14*Ag))*$(fc')^{0.5}$*D*de]	425137.80 **mm**
Reinforcement Shear Required	**: Vs_req**	= [(Vu / ϕv) - Vc]	341102.20
Reinforcement Shear Used	**: Vs**	= [(Av * fy * de) / b']	584366.39
Control	**:**	**Vs > Vs_req**	**OK**
	Smin		
Shear Reinforcement Used		**D16 - 100**	

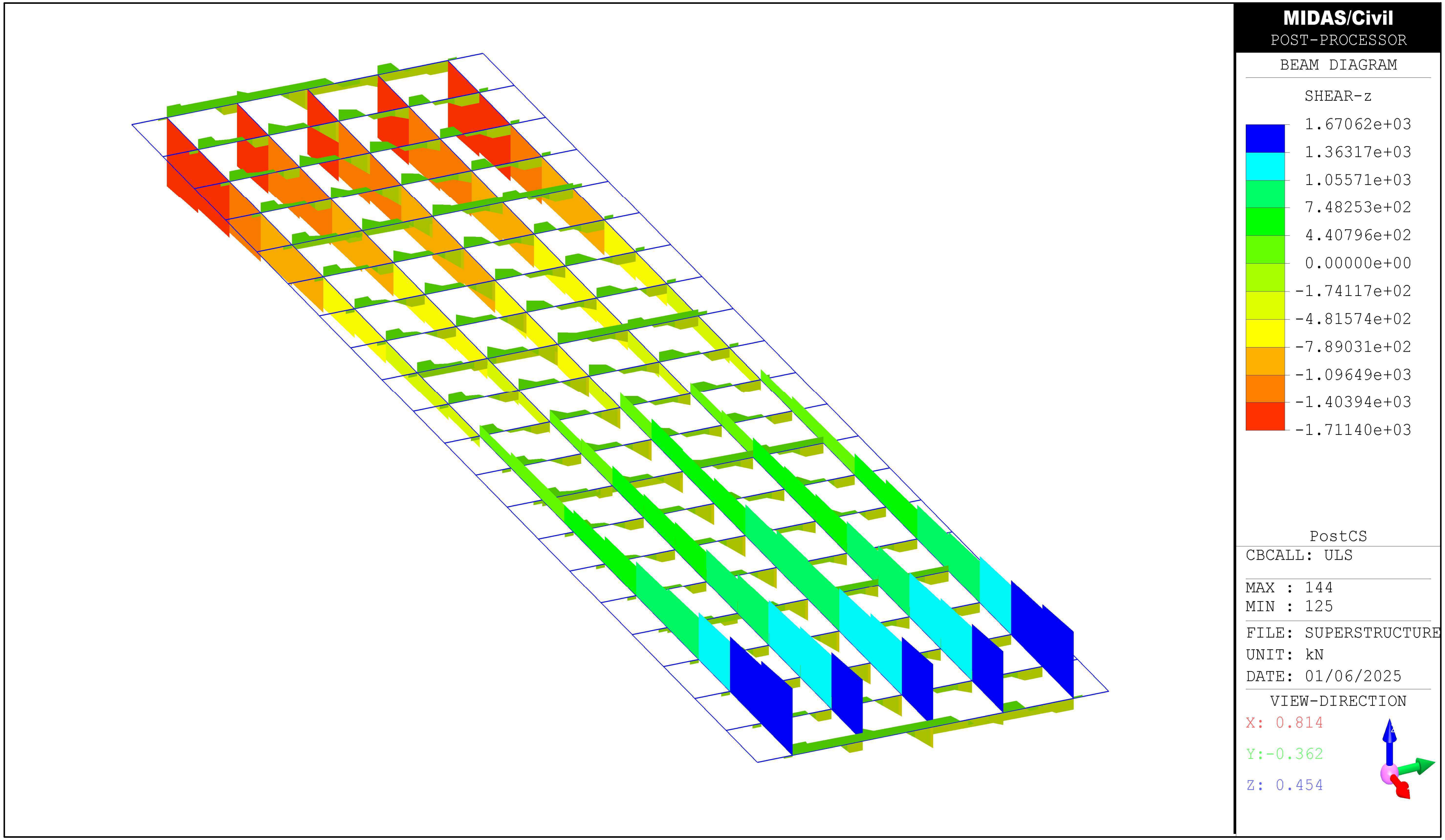
Recapitulation of Bridge Reinforcement			
Recapitulation of Superstructure Bridge Reinforcement			
1. PCI-Girder			
Flexure Reinforcement of Edge PCI-Girder	:	40D13	
Flexure Reinforcement of Middle PCI-Girder	:	26D13	
Specing of Field Reinforcement	:	D13-200	
Specing of Support Reinforcement	:	D13-100	
2. Floor Slab			
Longitudinal Flexure Reinforcement	:	D16 - 100	
Transverse Flexure Reinforcement	:	D13 - 100	
3. Diaphragm			
Flexure Reinforcement	:	D13 - 200	
Shear Reinforcement	:	D10 - 200	
4. Deck Slab			
Longitudinal Flexure Reinforcement	:	D10 - 200	
Transverse Flexure Reinforcement	:	D10 - 300	
Recapitulation of Substructure Bridge and Foundation Reinforcement			
1. Breast wall			
Axial - Flexure Reinforcement	:	D25 - 150	
Transversal Reinforcement	:	D16 - 150	
Shear Reinforcement	:	D16 - 300/600	
2. Back wall			
Longritudinal Flexure Reinforcement	:	D19 - 150	
Transversal Flexure Reinforcement	:	D13 - 150	
Shear Reinforcement	:	D13 - 300/400	
3. Wing wall			
Longitudinal Flexure Reinforcement	:	D16 - 150	
Transversal Flexure Reinforcement	:	D13 - 150	
Shear Reinforcement	:	D13 - 300/400	
4. Approach Slab			
Longitudinal Flexure Reinforcement	:	D16 - 200	
Transversal Flexure Reinforcement	:	D13 - 200	
Shear Reinforcement	:	D13 - 300/400	
5. Pilecap			
Longitudinal Flexure Reinforcement	:	D25 - 150	
Transversal Flexure Reinforcement	:	D19 - 150	
Shear Reinforcement	:	D16 - 300/600	
6. Pile			
Axial - Flexure Reinforcement	:	16D25	
Shear Reinforcement	:	D16 - 100	



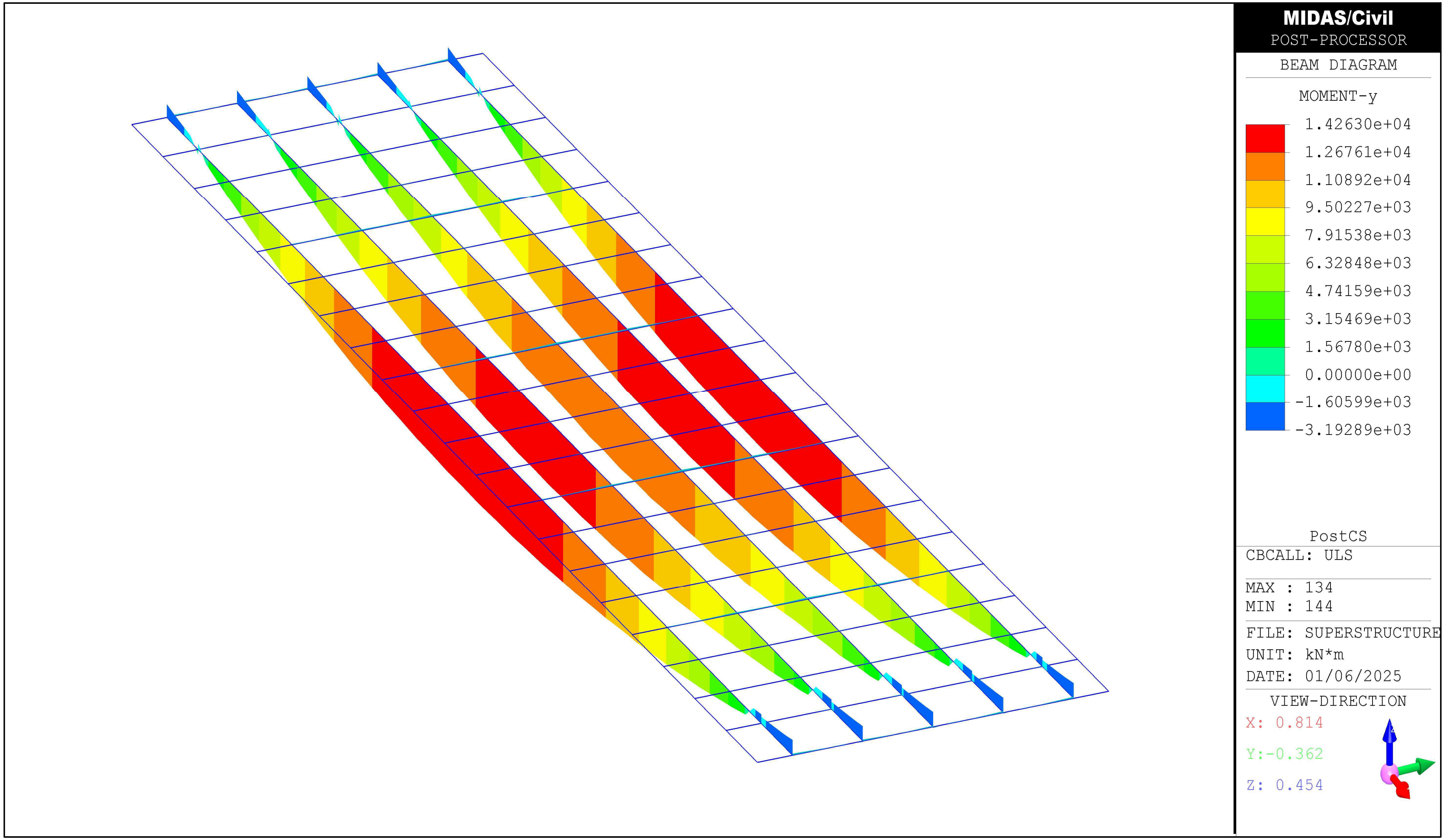
3-D View of Bridge Superstructure



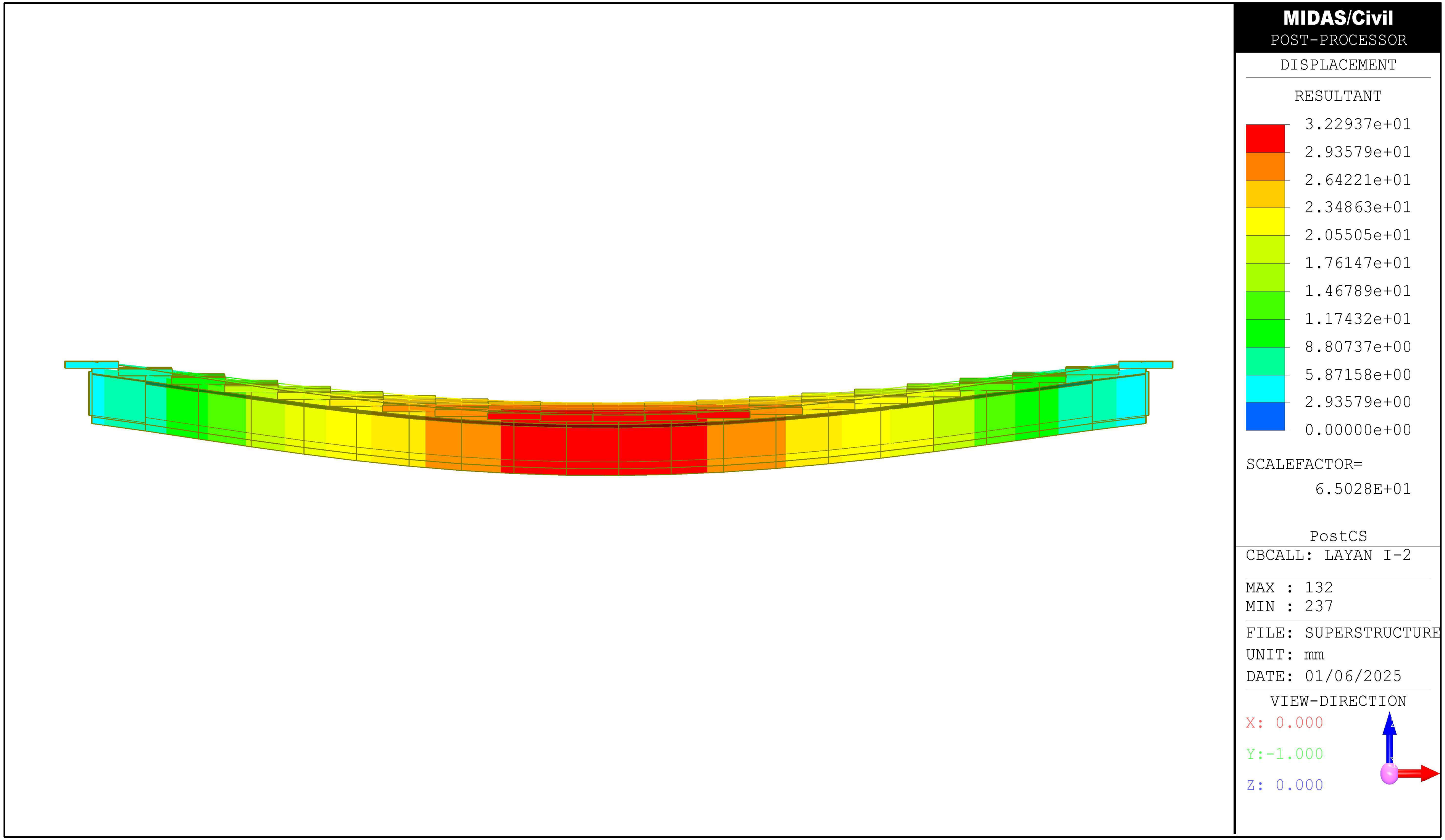
Axial Force Diagram



Shear Force Diagram



Moment Diagram



Bridge Superstructure Deformation

45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124
125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144

Label of Beam Girder

Eigenvalue Mode

Mode	UX	UY	UZ	RX	RY	RZ

EIGENVALUE ANALYSIS

Mode No	Frequency (rad/sec)	Frequency (cycle/sec)	Period (sec)	Tolerance
1	6.225725	0.990855	1.009229	0
2	10.250491	1.631416	0.612964	0
3	10.943496	1.741711	0.574148	0
4	10.943496	1.741711	0.574148	0
5	10.943497	1.741712	0.574148	0
6	10.943497	1.741712	0.574148	0
7	11.022165	1.754232	0.57005	0
8	11.022165	1.754232	0.57005	0
9	11.022165	1.754232	0.57005	0
10	11.022165	1.754232	0.57005	0
11	11.022165	1.754232	0.57005	0
12	11.022165	1.754232	0.57005	0
13	17.057198	2.714737	0.36836	0
14	32.278175	5.137231	0.194657	0
15	46.854978	7.457201	0.134099	0
16	57.858331	9.208439	0.108596	0
17	99.749257	15.875587	0.06299	0
18	102.880248	16.3739	0.061073	0
19	126.752197	20.173239	0.049571	0
20	127.330468	20.265273	0.049345	0

MODAL PARTICIPATION MASSES PRINTOUT

Mode No	TRAN-X MASS(%)	TRAN-X SUM(%)	TRAN-Y MASS(%)	TRAN-Y SUM(%)	TRAN-Z MASS(%)	TRAN-Z SUM(%)	ROTN-X MASS(%)	ROTN-X SUM(%)	ROTN-Y MASS(%)	ROTN-Y SUM(%)	ROTN-Z MASS(%)	ROTN-Z SUM(%)
1	81.42	81.42	0.00	0.00	0.05	0.05	0.00	0.00	1.43	1.43	0.00	0.00
2	0.00	81.42	79.14	79.14	0.00	0.05	1.88	1.88	0.00	1.43	0.00	0.00
3	0.00	81.42	0.00	79.14	0.00	0.05	0.00	1.88	0.00	1.43	8.70	8.70
4	0.00	81.42	0.00	79.14	0.00	0.05	0.00	1.88	0.00	1.43	8.70	17.40
5	0.00	81.42	0.00	79.14	0.00	0.05	0.00	1.88	0.00	1.43	8.70	26.10
6	0.00	81.42	0.00	79.14	0.00	0.05	0.00	1.88	0.00	1.43	8.70	34.80
7	0.00	81.42	0.00	79.14	0.00	0.05	0.00	1.88	0.00	1.43	8.70	43.50
8	0.00	81.42	0.00	79.14	0.00	0.05	0.00	1.88	0.00	1.43	8.70	52.20
9	0.00	81.42	0.00	79.14	0.00	0.05	0.00	1.88	0.00	1.43	8.70	60.90
10	0.00	81.42	0.00	79.14	0.00	0.05	0.00	1.88	0.00	1.43	8.70	69.60
11	0.00	81.42	0.00	79.14	0.00	0.05	0.00	1.88	0.00	1.43	8.70	78.30
12	0.00	81.42	0.00	79.14	0.00	0.05	0.00	1.88	0.00	1.43	8.71	87.00
13	0.00	81.42	0.14	79.28	0.00	0.05	0.06	1.95	0.00	1.43	1.31	88.32
14	0.09	81.51	0.00	79.28	99.74	99.79	0.00	1.95	0.00	1.43	0.00	88.32
15	0.00	81.51	11.38	90.66	0.00	99.79	4.39	6.34	0.00	1.43	0.00	88.32
16	9.08	90.58	0.00	90.66	0.10	99.89	0.00	6.34	0.70	2.12	0.00	88.32
17	0.00	90.58	0.00	90.66	0.00	99.89	3.01	9.35	0.00	2.12	0.01	88.33
18	0.07	90.66	0.00	90.66	0.01	99.90	0.00	9.35	0.01	2.13	0.00	88.33
19	0.00	90.66	0.00	90.67	0.00	99.90	0.08	9.43	0.00	2.13	0.01	88.33
20	0.00	90.66	0.00	90.67	0.00	99.90	0.00	9.43	0.19	2.32	0.00	88.33

Mode No	TRAN-X MASS	TRAN-X SUM	TRAN-Y MASS	TRAN-Y SUM	TRAN-Z MASS	TRAN-Z SUM	ROTN-X MASS	ROTN-X SUM	ROTN-Y MASS	ROTN-Y SUM	ROTN-Z MASS	ROTN-Z SUM
1	1208.77	1208.77	0.00	0.00	0.77	0.77	0.00	0.00	0.02	0.02	0.00	0.00
2	0.00	1208.77	1174.92	1174.92	0.00	0.77	0.07	0.07	0.00	0.02	0.00	0.00
3	0.00	1208.77	0.00	1174.92	0.00	0.77	0.00	0.07	0.00	0.02	1.51	1.51
4	0.00	1208.77	0.00	1174.92	0.00	0.77	0.00	0.07	0.00	0.02	1.51	3.01
5	0.00	1208.77	0.00	1174.92	0.00	0.77	0.00	0.07	0.00	0.02	1.51	4.52
6	0.00	1208.77	0.00	1174.92	0.00	0.77	0.00	0.07	0.00	0.02	1.51	6.03
7	0.00	1208.77	0.00	1174.92	0.00	0.77	0.00	0.07	0.00	0.02	1.51	7.54
8	0.00	1208.77	0.00	1174.92	0.00	0.77	0.00	0.07	0.00	0.02	1.51	9.04
9	0.00	1208.77	0.00	1174.92	0.00	0.77	0.00	0.07	0.00	0.02	1.51	10.55
10	0.00	1208.77	0.00	1174.92	0.00	0.77	0.00	0.07	0.00	0.02	1.51	12.06
11	0.00	1208.77	0.00	1174.92	0.00	0.77	0.00	0.07	0.00	0.02	1.51	13.56
12	0.00	1208.77	0.00	1174.92	0.00	0.77	0.00	0.07	0.00	0.02	1.51	15.07
13	0.00	1208.77	2.12	1177.03	0.00	0.77	0.00	0.07	0.00	0.02	0.23	15.30
14	1.34	1210.10	0.00	1177.03	1480.72	1481.49	0.00	0.07	0.00	0.02	0.00	15.30
15	0.00	1210.10	168.97	1346.00	0.00	1481.49	0.16	0.24	0.00	0.02	0.00	15.30
16	134.75	1344.85	0.00	1346.00	1.52	1483.01	0.00	0.24	0.01	0.03	0.00	15.30
17	0.00	1344.85	0.02	1346.02	0.00	1483.01	0.11	0.35	0.00	0.03	0.00	15.30
18	1.07	1345.92	0.00	1346.02	0.16	1483.17	0.00	0.35	0.00	0.03	0.00	15.30
19	0.00	1345.92	0.03	1346.05	0.00	1483.17	0.00	0.35	0.00	0.03	0.00	15.30
20	0.04	1345.96	0.00	1346.05	0.01	1483.17	0.00	0.35	0.00	0.03	0.00	15.30

Tendon Stress Limit Check

Tendon	Tendon Stress			Tendon Stress Limit		
	f_p1 (N/mm^2)	f_p2 (N/mm^2)	f_pe (N/mm^2)	Immediately after anchor set		At service
				At anch.	Away from anch.	
G1 - T1	1030.710	1283.274	1057.535	1302	1376.4	1339.2
G1 - T2	1044.095	1286.072	1058.451	1302	1376.4	1339.2
G1 - T3	1062.237	1289.793	1061.038	1302	1376.4	1339.2
G2 - T1	1030.710	1283.274	1056.360	1302	1376.4	1339.2
G2 - T2	1044.095	1286.072	1057.117	1302	1376.4	1339.2
G2 - T3	1062.237	1289.793	1059.660	1302	1376.4	1339.2
G3 - T1	1030.710	1283.274	1056.010	1302	1376.4	1339.2
G3 - T2	1044.095	1286.072	1056.800	1302	1376.4	1339.2
G3 - T3	1062.237	1289.793	1059.234	1302	1376.4	1339.2
G4 - T1	1030.710	1283.274	1056.582	1302	1376.4	1339.2
G4 - T2	1044.095	1286.072	1057.487	1302	1376.4	1339.2
G4 - T3	1062.237	1289.793	1059.874	1302	1376.4	1339.2
G5 - T1	1030.710	1283.274	1057.982	1302	1376.4	1339.2
G5 - T2	1044.095	1286.072	1059.078	1302	1376.4	1339.2
G5 - T3	1062.237	1289.793	1061.564	1302	1376.4	1339.2

Tendon Stress

f_p1 (N/mm2): Maximum stress in tendon at both anchorages immediately after anchor set (only for post-tensioning)

f_p2 (N/mm2): Maximum stress in tendon along the length of the member away from the anchorages immediately after anchor set (only for post-tensioning)

f_pe (N/mm2): Maximum stress in tendon after all losses, which is obtained at the last construction stage

Tendon Stress Limit

Immediately after anchor set

At anch.: Stress limits for prestressing tendons at anchorages immediately after anchor set

Away from anch.: Stress limits for prestressing tendons elsewhere along the length of the member away from anchorages immediately after anchor set

At service: Stress limits for prestressing tendons at the service limit state, after losses

Stress Check at service load

Elem	Part	Girder/Slab	Comp./Tens.	LCom Name	Type	CHK	FT (kN/m^2)	FB (kN/m^2)	FTL (kN/m^2)	FBL (kN/m^2)	FTR (kN/m^2)	FBR (kN/m^2)	FMAX (kN/m^2)	ALW (kN/m^2)
85	I[5]	Girder(Composite)	Compression	Layan I-1	MZ-MAX	OK	738.153	6243.881	636.521	6154.953	839.786	6332.809	6332.809	30000.000
85	I[5]	Girder(Composite)	Tension	Layan III-1	MZ-MAX	OK	739.143	6240.510	682.329	6190.798	795.958	6290.223	682.329	-3527.753
85	J[28]	Girder(Composite)	Compression	Layan I-3	FZ-MAX	OK	1628.110	4805.015	1652.042	4825.956	1604.177	4784.074	4825.956	30000.000
85	J[28]	Girder(Composite)	Tension	Layan III-2	FZ-MAX	OK	1619.213	4818.311	1621.332	4820.165	1617.094	4816.457	1617.094	-3527.753
86	I[28]	Girder(Composite)	Compression	Layan I-4	MY-MIN	OK	2398.675	7013.288	2422.923	7034.504	2374.408	6992.053	7034.504	30000.000
86	I[28]	Girder(Composite)	Tension	Layan III-1	MY-MIN	OK	2386.912	7026.721	2387.287	7027.048	2386.537	7026.393	2386.537	-3527.753
86	J[39]	Girder(Composite)	Compression	Layan I-3	MY-MIN	OK	3186.830	5547.174	3216.205	5572.875	3157.432	5521.450	5572.875	30000.000
86	J[39]	Girder(Composite)	Tension	Layan III-2	MY-MIN	OK	4321.570	3107.715	4323.662	3109.546	4319.476	3105.883	3105.883	-3527.753
87	I[39]	Girder(Composite)	Compression	Layan I-4	MY-MIN	OK	3195.932	5539.244	3215.982	5556.787	3175.866	5521.685	5556.787	30000.000
87	I[39]	Girder(Composite)	Tension	Layan III-2	MY-MIN	OK	4318.735	3107.080	4319.534	3107.779	4317.936	3106.380	3106.380	-3527.753
87	J[50]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	5744.144	338.452	5771.402	362.301	5716.865	314.581	5771.402	30000.000
87	J[50]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	5344.059	1182.027	5345.981	1183.708	5342.136	1180.344	1180.344	-3527.753
88	I[50]	Girder(Composite)	Compression	Layan I-2	MY-MAX	OK	5724.396	345.249	5741.131	359.892	5707.647	330.593	5741.131	30000.000
88	I[50]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	5326.896	1186.873	5327.905	1187.756	5325.885	1185.989	1185.989	-3527.753
88	J[61]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	6578.653	-1196.924	6603.332	-1175.331	6553.955	-1218.536	6603.332	30000.000
88	J[61]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	6120.506	-233.941	6122.692	-232.028	6118.318	-235.855	-235.855	-3527.753
89	I[61]	Girder(Composite)	Compression	Layan I-2	MY-MAX	OK	6573.816	-1194.922	6588.826	-1181.788	6558.794	-1208.067	6588.826	30000.000
89	I[61]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	6115.010	-233.025	6116.428	-231.784	6113.591	-234.267	-234.267	-3527.753
89	J[72]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	7475.909	-2819.347	7497.689	-2800.291	7454.112	-2838.421	7497.689	30000.000
89	J[72]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	6917.347	-1655.691	6918.563	-1654.627	6916.130	-1656.756	-1656.756	-3527.753
90	I[72]	Girder(Composite)	Compression	Layan I-2	MY-MAX	OK	7486.401	-2820.673	7497.688	-2810.797	7475.105	-2830.557	7497.688	30000.000
90	I[72]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	6924.319	-1656.684	6925.885	-1655.314	6922.752	-1658.056	-1658.056	-3527.753
90	J[83]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	8147.868	-3934.698	8167.668	-3917.374	8128.053	-3952.037	8167.668	30000.000
90	J[83]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	7517.540	-2634.513	7519.285	-2632.986	7515.794	-2636.041	-2636.041	-3527.753
91	I[83]	Girder(Composite)	Compression	Layan I-2	MY-MAX	OK	8145.300	-3930.883	8153.367	-3923.824	8137.226	-3937.948	8153.367	30000.000
91	I[83]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	7514.357	-2631.110	7516.175	-2629.520	7512.538	-2632.702	-2632.702	-3527.753
91	J[94]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	8570.223	-4548.980	8588.099	-4533.340	8552.334	-4564.634	8588.099	30000.000
91	J[94]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	7903.687	-3180.090	7906.370	-3177.742	7901.001	-3182.440	-3182.440	-3527.753
92	I[94]	Girder(Composite)	Compression	Layan I-2	MY-MAX	OK	8555.935	-4540.742	8561.657	-4535.735	8550.209	-4545.753	8561.657	30000.000
92	I[94]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	7891.806	-3173.035	7894.538	-3170.645	7889.072	-3175.428	-3175.428	-3527.753
92	J[105]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	8762.432	-4707.072	8779.479	-4692.156	8745.372	-4722.000	8779.479	30000.000
92	J[105]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	8093.717	-3332.864	8098.574	-3328.614	8088.856	-3337.117	-3337.117	-3527.753
93	I[105]	Girder(Composite)	Compression	Layan I-2	MY-MAX	OK	8759.367	-4701.689	8765.795	-4696.065	8752.934	-4707.318	8765.795	30000.000
93	I[105]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	8090.104	-3327.555	8096.452	-3322.001	8083.751	-3333.114	-3333.114	-3527.753
93	J[116]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	9021.919	-4979.750	9032.965	-4970.085	9010.864	-4989.424	9032.965	30000.000
93	J[116]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	8306.085	-3512.034	8307.771	-3510.559	8304.398	-3513.510	-3513.510	-3527.753
94	I[116]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	9030.689	-4977.259	9039.131	-4969.873	9022.240	-4984.652	9039.131	30000.000
94	I[116]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	8311.553	-3508.492	8316.743	-3503.952	8306.360	-3513.036	-3513.036	-3527.753
94	J[127]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	9101.195	-4862.526	9110.063	-4854.767	9092.320	-4870.292	9110.063	30000.000
94	J[127]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	8366.106	-3361.806	8368.555	-3359.662	8363.654	-3363.951	-3363.951	-3527.753
95	I[127]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	9100.761	-4856.680	9111.844	-4846.983	9089.669	-4866.386	9111.844	30000.000
95	I[127]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	8365.671	-3355.959	8370.336	-3351.878	8361.003	-3360.045	-3360.045	-3527.753
95	J[138]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	8984.846	-4365.614	8992.160	-4359.214	8977.526	-4372.019	8992.160	30000.000
95	J[138]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	8265.710	-2896.846	8269.771	-2893.293	8261.645	-2900.403	-2900.403	-3527.753
96	I[138]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	8975.320	-4357.607	8989.306	-4345.369	8961.322	-4369.855	8989.306	30000.000
96	I[138]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	8259.486	-2889.890	8264.112	-2885.843	8254.857	-2893.942	-2893.942	-3527.753
96	J[149]	Girder(Composite)	Compression	Layan I-2	MY-MAX	OK	8677.111	-3501.926	8683.719	-3496.144	8670.498	-3507.713	8683.719	30000.000
96	J[149]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	8007.848	-2127.792	8014.376	-2122.080	8001.314	-2133.510	-2133.510	-3527.753
97	I[149]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	8679.580	-3498.133	8699.590	-3480.626	8659.556	-3515.655	8699.590	30000.000
97	I[149]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	8010.866	-2123.925	8018.685	-2117.083	8003.040	-2130.772	-2130.772	-3527.753
97	J[160]	Girder(Composite)	Compression	Layan I-2	MY-MAX	OK	8454.738	-2797.282	8461.335	-2791.511	8448.137	-2803.058	8461.335	30000.000
97	J[160]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	7790.609	-1429.575	7794.215	-1426.420	7787.000	-1432.733	-1432.733	-3527.753
98	I[160]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	8468.606	-2797.707	8489.677	-2779.271	8447.519	-2816.159	8489.677	30000.000
98	I[160]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	7802.069	-1428.817	7807.948	-1423.674	7796.186	-1433.965	-1433.965	-3527.753
98	J[171]	Girder(Composite)	Compression	Layan I-2	MY-MAX	OK	8048.716	-1700.303	8058.871	-1691.418	8038.553	-1709.196	8058.871	30000.000
98	J[171]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	7417.773	-400.531	7421.678	-397.114	7413.865	-403.951	-403.951	-3527.753
99	I[171]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	8051.029	-1697.662	8074.768	-1676.891	8027.270	-1718.452	8074.768	30000.000
99	I[171]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	7420.701	-397.477	7426.385	-392.504	7415.012	-402.456	-402.456	-3527.753
99	J[182]	Girder(Composite)	Compression	Layan I-2	MY-MAX	OK	7432.338	-490.238	7446.086	-478.209	7418.579	-502.277	7446.086	30000.000
99	J[182]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	6870.256	673.751	6874.283	677.274	6866.227	670.225	670.225	-3527.753
100	I[182]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	7421.739	-483.775	7445.397	-463.075	7398.062	-504.494	7445.397	30000.000
100	I[182]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	6863.176	679.881	6866.271	682.589	6860.079	677.172	677.172	-3527.753
100	J[193]	Girder(Composite)	Compression	Layan I-2	MY-MAX	OK	6577.504	984.316	6596.152	1000.632	6558.841	967.985	6596.152	30000.000
100	J[193]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	6118.698	1946.213	6123.754	1950.636	6113.638	1941.785	1941.785	-3527.753
101	I[193]	Girder(Composite)	Compression	Layan I-1	MY-MAX	OK	6582.431	986.175	6608.493	1008.979	6556.349	963.352	6608.493	30000.000
101	I[193]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	6124.284	1949.159	6127.853	1952.281	6120.712	1946.033	1946.033	-3527.753
101	J[204]	Girder(Composite)	Compression	Layan I-4	MY-MIN	OK	3948.245	6302.538	3968.766	6320.494	3927.708	6284.567	6320.494	30000.000
101	J[204]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	5392.729	3198.583	5397.473	3202.733	5387.982	3194.428	3194.428	-3527.753
102	I[204]	Girder(Composite)	Compression	Layan I-3	MY-MIN	OK	3954.447	6305.570	3982.320	6329.957	3926.553	6281.161	6329.957	30000.000
102	I[204]	Girder(Composite)	Tension	Layan III-1	MY-MAX	OK	5410.139	3196.404	5412.646	3198.598	5407.629	3194.208	3194.208	-3527.753
102	J[215]	Girder(Composite)	Compression	Layan I-4	MY-MIN	OK	3325.857	7372.296	3348.983	7392.530	3302.714	7352.044	7392.530	30000.000
102	J[215]	Girder(Composite)	Tension	Layan III-2	MY-MIN	OK	3305.761	7406.339	3309.665	7409.755	3301.855	7402.920	3301.855	-3527.753
103	I[215]	Girder(Composite)	Compression	Layan I-3	MY-MIN	OK	3316.991	7381.864	3346.061	7407.299	3287.898	7356.406	7407.299	30000.000
103	I[215]	Girder(Composite)	Tension	Layan III-2	MY-MIN	OK	3297.663	7415.996	3299.487	7417.591	3295.839	7414.400	3295.839	-3527.753
103	J[226]	Girder(Composite)	Compression	Layan I-4	MY-MIN	OK	2592.308	8661.406	2618.798	8684.584	2565.797	8638.207	8684.584	30000.000
103	J[226]	Girder(Composite)	Tension	Layan III-1	MY-MIN	OK	2580.545	8674.839	2583.162	8677.128	2577.926	8672.547	2577.926	-3527.753

Stress Check at service load

Elem	Part	Girder/Slab	Comp./Tens.	LCom Name	Type	CHK	FT (kN/m^2)	FB (kN/m^2)	FTL (kN/m^2)	FBL (kN/m^2)	FTR (kN/m^2)	FBR (kN/m^2)	FMAX (kN/m^2)	ALW (kN/m^2)
104	I[226]	Girder(Composite)	Compression	Layan I-3	FZ-MIN	OK	1699.137	5993.123	1722.308	6013.398	1675.966	5972.849	6013.398	30000.000
104	I[226]	Girder(Composite)	Tension	Layan III-2	FZ-MIN	OK	1690.240	6006.420	1691.597	6007.607	1688.883	6005.232	1688.883	-3527.753
104	J[6]	Girder(Composite)	Compression	Layan I-1	MZ-MAX	OK	870.142	7287.427	769.895	7199.711	970.388	7375.142	7375.142	30000.000
104	J[6]	Girder(Composite)	Tension	Layan III-1	MZ-MAX	OK	871.132	7284.056	815.703	7235.556	926.560	7332.556	815.703	-3527.753

Elem: Element number

Part: Check location (I-End, J-End) of each element

Comp./Tens.: Compression or Tension Stress

Stage: Construction stage at which stresses are maximum at the corresponding section.

CHK: Combined stress check for construction stages

FT: Combined Stress due to bending moment about major axis (My) and axial force at Top fiber

FB: Combined Stress due to bending moment about major axis (My) and axial force at Bottom fiber

FTL: Combined Stress due to bending moment about major axis (My), minor axis (Mz) and axial force at Top Left fiber

FBL: Combined Stress due to bending moment about major axis (My), minor axis (Mz) and axial force at Bottom Left fiber

FTR: Combined Stress due to bending moment about major axis (My), minor axis (Mz) and axial force at Top Right fiber

FBR: Combined Stress due to bending moment about major axis (My), minor axis (Mz) and axial force at Bottom Right fiber

FMAX: Maximum combined stress out of the above six.

ALW: Allowable stress of cross section at construction stage

Flexure Strength Check

Elem	Part	Positive/ Negative	LComName	Type	CHK	Muy (kN*m)	Mcr (kN*m)	Mny (kN*m)	PhiMny (kN*m)	Ratio (Muy/PhiMny)	PhiMny/ min(1.33Muy,Mcr)
85	I[5]	Negative	Kuat I-1	MY-MIN	OK	-2673.138	5112.823	5897.118	5897.118	0.453	1.659
85	I[5]	Positive	Ekstrem I-3	FZ-MAX	OK	0.000	9159.613	14550.826	14550.826	0.000	larger than 100
85	J[28]	Negative	Ekstrem II-2	FZ-MAX	OK	-1011.609	4539.804	4944.879	4800.824	0.211	3.568
85	J[28]	Positive	Kuat I-1	MY-MAX	OK	1021.336	9815.010	15584.886	15584.886	0.066	11.473
86	I[28]	Negative	Ekstrem II-2	MY-MIN	OK	-1433.339	4880.191	4944.615	4804.965	0.298	2.521
86	I[28]	Positive	Kuat I-1	MY-MAX	OK	578.917	9835.464	15584.886	15584.886	0.037	20.241
86	J[39]	Negative	Ekstrem II-2	MY-MIN	OK	-49.810	4321.713	4028.469	3629.375	0.014	54.785
86	J[39]	Positive	Kuat I-1	MY-MAX	OK	3493.904	10513.326	16599.731	16599.731	0.211	3.572
87	I[39]	Negative	Ekstrem II-2	MY-MIN	OK	-43.538	4321.680	4028.469	3629.375	0.012	62.678
87	I[39]	Positive	Kuat I-1	MY-MAX	OK	3487.779	10513.856	16599.731	16599.731	0.210	3.579
87	J[50]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	3770.084	3174.770	2639.420	0.000	larger than 100
87	J[50]	Positive	Kuat I-1	MY-MAX	OK	5778.350	11183.247	17573.917	17573.917	0.329	2.287
88	I[50]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	3770.026	3174.770	2639.420	0.000	larger than 100
88	I[50]	Positive	Kuat I-1	MY-MAX	OK	5770.376	11183.885	17573.917	17573.917	0.328	2.290
88	J[61]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	3236.774	2403.851	1842.161	0.000	larger than 100
88	J[61]	Positive	Kuat I-1	MY-MAX	OK	7510.958	11834.544	18486.309	18486.309	0.406	1.851
89	I[61]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	3236.635	2403.851	1842.161	0.000	larger than 100
89	I[61]	Positive	Kuat I-1	MY-MAX	OK	7512.302	11835.429	18486.309	18486.309	0.406	1.850
89	J[72]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	2736.995	1739.625	1304.719	0.000	larger than 100
89	J[72]	Positive	Kuat I-1	MY-MAX	OK	9390.817	12444.953	19316.338	19316.338	0.486	1.552
90	I[72]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	2736.812	1739.625	1304.719	0.000	larger than 100
90	I[72]	Positive	Kuat I-1	MY-MAX	OK	9400.702	12445.862	19316.338	19316.338	0.487	1.552
90	J[83]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	2284.731	1198.631	898.973	0.000	larger than 100
90	J[83]	Positive	Kuat I-1	MY-MAX	OK	10773.464	13003.270	20041.960	20041.960	0.538	1.541
91	I[83]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	2284.466	1198.631	898.973	0.000	larger than 100
91	I[83]	Positive	Kuat I-1	MY-MAX	OK	10774.220	13004.359	20041.960	20041.960	0.538	1.541
91	J[94]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1895.786	793.487	595.115	0.000	larger than 100
91	J[94]	Positive	Kuat I-1	MY-MAX	OK	11636.337	13492.734	20643.196	20643.196	0.564	1.530
92	I[94]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1895.417	793.487	595.115	0.000	larger than 100
92	I[94]	Positive	Kuat I-1	MY-MAX	OK	11628.005	13494.067	20643.196	20643.196	0.563	1.530
92	J[105]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1586.495	522.572	391.929	0.000	larger than 100
92	J[105]	Positive	Kuat I-1	MY-MAX	OK	12006.556	13896.580	21098.303	21098.303	0.569	1.518
93	I[105]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1586.050	522.572	391.929	0.000	larger than 100
93	I[105]	Positive	Kuat I-1	MY-MAX	OK	12005.155	13898.072	21098.303	21098.303	0.569	1.518
93	J[116]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1378.299	375.482	281.612	0.000	larger than 100
93	J[116]	Positive	Kuat I-1	MY-MAX	OK	12551.652	14183.066	21386.597	21386.597	0.587	1.508
94	I[116]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1377.792	375.482	281.612	0.000	larger than 100
94	I[116]	Positive	Kuat I-1	MY-MAX	OK	12557.429	14184.696	21386.597	21386.597	0.587	1.508
94	J[127]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1282.862	329.469	247.102	0.000	larger than 100
94	J[127]	Positive	Kuat I-1	MY-MAX	OK	12648.849	14351.701	21487.424	21487.424	0.589	1.497
95	I[127]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1282.238	329.469	247.102	0.000	larger than 100
95	I[127]	Positive	Kuat I-1	MY-MAX	OK	12646.241	14353.670	21487.424	21487.424	0.589	1.497
95	J[138]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1312.239	375.482	281.612	0.000	larger than 100
95	J[138]	Positive	Kuat I-1	MY-MAX	OK	12283.418	14390.459	21386.597	21386.597	0.574	1.486
96	I[138]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1311.643	375.482	281.612	0.000	larger than 100
96	I[138]	Positive	Kuat I-1	MY-MAX	OK	12272.972	14392.362	21386.597	21386.597	0.574	1.486
96	J[149]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1461.718	522.572	391.929	0.000	larger than 100
96	J[149]	Positive	Kuat I-1	MY-MAX	OK	11471.777	14302.681	21098.303	21098.303	0.544	1.475
97	I[149]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1461.239	522.572	391.929	0.000	larger than 100
97	I[149]	Positive	Kuat I-1	MY-MAX	OK	11469.130	14304.282	21098.303	21098.303	0.544	1.475
97	J[160]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1724.795	793.487	595.115	0.000	larger than 100
97	J[160]	Positive	Kuat I-1	MY-MAX	OK	10862.546	14085.048	20643.196	20643.196	0.526	1.466
98	I[160]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	1724.432	793.487	595.115	0.000	larger than 100
98	I[160]	Positive	Kuat I-1	MY-MAX	OK	10867.475	14086.359	20643.196	20643.196	0.526	1.466
98	J[171]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	2084.631	1198.631	898.973	0.000	larger than 100
98	J[171]	Positive	Kuat I-1	MY-MAX	OK	9811.691	13765.251	20041.960	20041.960	0.490	1.536

Flexure Strength Check

Elem	Part	Positive/ Negative	LComName	Type	CHK	Muy (kN*m)	Mcr (kN*m)	Mny (kN*m)	PhiMny (kN*m)	Ratio (Muy/PhiMny)	PhiMny/ min(1.33Muy,Mcr)
99	I[171]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	2084.360	1198.631	898.973	0.000	larger than 100
99	I[171]	Positive	Kuat I-1	MY-MAX	OK	9808.164	13766.351	20041.960	20041.960	0.489	1.536
99	J[182]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	2552.981	1739.625	1304.719	0.000	larger than 100
99	J[182]	Positive	Kuat I-1	MY-MAX	OK	8418.243	13255.181	19316.338	19316.338	0.436	1.725
100	I[182]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	2552.804	1739.625	1304.719	0.000	larger than 100
100	I[182]	Positive	Kuat I-1	MY-MAX	OK	8406.195	13256.038	19316.338	19316.338	0.435	1.728
100	J[193]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	3094.401	2403.851	1842.161	0.000	larger than 100
100	J[193]	Positive	Kuat I-1	MY-MAX	OK	6619.706	12611.844	18486.309	18486.309	0.358	2.100
101	I[193]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	3094.333	2403.851	1842.161	0.000	larger than 100
101	I[193]	Positive	Kuat I-1	MY-MAX	OK	6616.831	12612.334	18486.309	18486.309	0.358	2.101
101	J[204]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	3675.303	3174.770	2639.420	0.000	larger than 100
101	J[204]	Positive	Kuat I-1	MY-MAX	OK	4975.900	11919.675	17573.917	17573.917	0.283	2.656
102	I[204]	Negative	Ekstrem II-2	MY-MIN	OK	0.000	3675.279	3174.770	2639.420	0.000	larger than 100
102	I[204]	Positive	Kuat I-1	MY-MAX	OK	4982.923	11920.022	17573.917	17573.917	0.284	2.652
102	J[215]	Negative	Ekstrem II-2	MY-MIN	OK	-735.367	4279.148	4028.469	3629.375	0.203	3.711
102	J[215]	Positive	Kuat I-1	MY-MAX	OK	2795.950	11202.723	16599.731	16599.731	0.168	4.464
103	I[215]	Negative	Ekstrem II-2	MY-MIN	OK	-742.216	4279.182	4028.469	3629.375	0.205	3.677
103	I[215]	Positive	Kuat I-1	MY-MAX	OK	2801.498	11202.833	16599.731	16599.731	0.169	4.455
103	J[226]	Negative	Ekstrem II-2	MY-MIN	OK	-2021.048	4892.798	4944.615	4804.965	0.421	1.788
103	J[226]	Positive	Kuat I-1	MY-MAX	OK	0.000	10477.063	15584.886	15584.886	0.000	larger than 100
104	I[226]	Negative	Ekstrem II-2	FZ-MIN	OK	-1525.317	4500.478	4944.879	4800.824	0.318	2.367
104	I[226]	Positive	Kuat I-1	MY-MAX	OK	507.626	10375.249	15584.886	15584.886	0.033	23.084
104	J[6]	Negative	Kuat I-1	MY-MIN	OK	-3094.337	5129.744	5897.118	5897.118	0.525	1.433
104	J[6]	Positive	Ekstrem I-3	FZ-MIN	OK	0.000	9664.788	14550.826	14550.826	0.000	larger than 100

Elem: Element number

Part: Check location (I-End, J-End) of each element

Positive/Negative: Positive moment, negative moment

LCom. Name: Load combination name.

Type: Displays the set of member forces corresponding to moving load case or settlement load case for which the maximum stresses are produced. If it is not defined then this field is left blank(-)

CHK: Flexural strength check for element

Muy: Factored moment acting at section about y axis

Mcr: Cracking moment of section (Refer to the equation 5.7.3.3.2-1 of AASHTO LRFD (2012).)

Mny: Nominal moment resistance of section about y axis

PhiMny: Design moment resistance of section about y axis

Ratio (Muy/PhiMny): Flexural resistance ratio, The verification is satisfied when it is less than 1.0.

PhiMny/min(1.33Muy,Mcr): Verification of minimum reinforcement. The verification is satisfied when it is less than 1.0. If the verification of minimum reinforcement is not required, it will be displayed as 1.0. (Refer to the clause 5.7.3.3.2 of AASHTO LRFD (2012).)

Shear Strength Check

Elem	Part	Max/Min	LCom Name	Type	CHK	Vu (kN)	Mu (kN*m)	Vn (kN)	Phi	Vc (kN)	Vs (kN)	Vp (kN)	PhiVn (kN)
85	I[5]	Max	Ekstrem I-3	FZ-MAX	OK	-793.709	-1542.627	3805.506	0.900	2859.068	6517.427	254.286	8668.495
85	I[5]	Min	Kuat I-1	MY-MIN	OK	-1834.219	-2673.138	3805.506	0.900	2859.068	6517.427	254.286	8668.495
85	J[28]	Max	Ekstrem I-3	FZ-MAX	OK	-684.569	-105.531	3806.385	0.900	2859.068	6517.427	255.166	8668.495
85	J[28]	Min	Kuat I-1	MY-MAX	OK	-1810.102	1021.336	9631.661	0.900	2859.068	6517.427	255.166	8668.495
86	I[28]	Max	Ekstrem I-3	FZ-MAX	OK	-659.764	-162.455	1224.142	0.900	1186.513	1629.357	250.565	2756.576
86	I[28]	Min	Kuat I-1	FZ-MIN	NG	-1376.531	-314.385	1224.142	0.900	1186.513	1629.357	250.565	2756.576
86	J[39]	Max	Ekstrem I-3	FZ-MAX	OK	-584.741	1026.457	3062.863	0.900	1186.513	1629.357	246.993	2756.576
86	J[39]	Min	Kuat I-1	MY-MAX	OK	-1534.674	3493.904	3062.863	0.900	1186.513	1629.357	246.993	2756.576
87	I[39]	Max	Ekstrem I-3	FZ-MAX	OK	-551.190	1504.263	3062.882	0.900	1186.513	1629.357	247.012	2756.593
87	I[39]	Min	Kuat I-1	FZ-MIN	OK	-1199.027	1853.515	3062.882	0.900	1186.513	1629.357	247.012	2756.593
87	J[50]	Max	Ekstrem I-3	FZ-MAX	OK	-481.363	2470.775	3138.817	0.900	1222.288	1678.484	238.046	2824.936
87	J[50]	Min	Kuat I-1	MY-MAX	OK	-1277.173	5778.350	3138.817	0.900	1222.288	1678.484	238.046	2824.936
88	I[50]	Max	Ekstrem I-3	FZ-MAX	OK	-362.300	3284.623	3138.841	0.900	1222.288	1678.484	238.069	2824.957
88	I[50]	Min	Kuat I-1	FZ-MIN	OK	-1061.820	4282.227	3138.841	0.900	1222.288	1678.484	238.069	2824.957
88	J[61]	Max	Ekstrem I-3	FZ-MAX	OK	-297.950	3867.971	3269.275	0.900	1283.417	1762.428	223.431	2942.348
88	J[61]	Min	Kuat I-1	MY-MAX	OK	-1034.762	7510.958	3269.275	0.900	1283.417	1762.428	223.431	2942.348
89	I[61]	Max	Ekstrem I-3	FZ-MAX	OK	-321.202	3624.560	3269.303	0.900	1283.417	1762.428	223.459	2942.373
89	I[61]	Min	Kuat I-2	FZ-MIN	OK	-1043.595	5089.175	3269.303	0.900	1283.417	1762.428	223.459	2942.373
89	J[72]	Max	Ekstrem I-3	FZ-MAX	OK	-262.633	4120.435	3380.370	0.900	1338.981	1838.730	202.658	3042.333
89	J[72]	Min	Kuat I-1	MY-MAX	OK	-1091.622	9390.817	3380.370	0.900	1338.981	1838.730	202.658	3042.333
90	I[72]	Max	Ekstrem I-3	FZ-MAX	OK	-184.713	6272.660	3380.395	0.900	1338.981	1838.730	202.683	3042.355
90	I[72]	Min	Kuat I-2	FZ-MIN	OK	-869.162	6473.982	3380.395	0.900	1338.981	1838.730	202.683	3042.355
90	J[83]	Max	Ekstrem I-3	FZ-MAX	OK	-132.252	6490.599	3468.892	0.900	1387.699	1905.632	175.561	3122.003
90	J[83]	Min	Kuat I-1	MY-MAX	OK	-858.965	10773.464	3468.892	0.900	1387.699	1905.632	175.561	3122.003
91	I[83]	Max	Ekstrem I-3	FZ-MAX	OK	-34.351	7455.532	3468.916	0.900	1387.699	1905.632	175.586	3122.025
91	I[83]	Min	Kuat I-2	FZ-MIN	OK	-715.901	7419.673	3468.916	0.900	1387.699	1905.632	175.586	3122.025
91	J[94]	Max	Ekstrem I-3	FZ-MAX	OK	11.654	7368.497	3247.058	0.900	1427.994	1960.965	141.901	2922.352
91	J[94]	Min	Kuat I-2	FZ-MIN	OK	-669.897	8695.740	3530.861	0.900	1427.994	1960.965	141.901	3177.775
92	I[94]	Max	Ekstrem I-3	FZ-MAX	OK	127.028	8256.471	3247.036	0.900	1427.994	1960.965	141.924	2922.332
92	I[94]	Min	Kuat I-2	FZ-MIN	OK	-579.882	8007.990	3530.883	0.900	1427.994	1960.965	141.924	3177.795
92	J[105]	Max	Ekstrem I-3	FZ-MAX	OK	166.204	7843.474	3359.999	0.900	1458.560	2002.939	101.500	3023.999
92	J[105]	Min	Kuat I-2	FZ-MIN	OK	-540.706	9008.812	3562.999	0.900	1458.560	2002.939	101.500	3206.699
93	I[105]	Max	Kuat I-2	FZ-MAX	OK	137.721	8632.853	3359.982	0.900	1458.560	2002.939	101.517	3023.984
93	I[105]	Min	Kuat I-2	FZ-MIN	OK	-565.760	8372.902	3563.016	0.900	1458.560	2002.939	101.517	3206.714
93	J[116]	Max	Kuat I-2	FZ-MAX	OK	169.675	8196.697	3453.353	0.900	1477.946	2029.561	54.154	3108.018
93	J[116]	Min	Kuat I-2	FZ-MIN	OK	-533.806	9343.707	3561.661	0.900	1477.946	2029.561	54.154	3205.495
94	I[116]	Max	Kuat I-2	FZ-MAX	OK	259.075	9040.582	3453.343	0.900	1477.946	2029.561	54.164	3108.009
94	I[116]	Min	Kuat I-2	FZ-MIN	OK	-414.340	8601.744	3561.671	0.900	1477.946	2029.561	54.164	3205.504
94	J[127]	Max	Kuat I-2	FZ-MAX	OK	283.406	8361.791	3523.553	0.900	1484.707	2038.846	0.000	3171.198
94	J[127]	Min	Kuat I-2	FZ-MIN	OK	-390.009	9269.783	3523.553	0.900	1484.707	2038.846	0.000	3171.198
95	I[127]	Max	Kuat I-2	FZ-MAX	OK	384.799	9162.719	3523.553	0.900	1484.707	2038.846	0.000	3171.198
95	I[127]	Min	Kuat I-2	FZ-MIN	OK	-287.463	8442.611	3523.553	0.900	1484.707	2038.846	0.000	3171.198
95	J[138]	Max	Kuat I-2	FZ-MAX	OK	407.018	8233.266	3452.293	0.900	1477.946	2029.561	-55.214	3107.064
95	J[138]	Min	Kuat I-2	FZ-MIN	OK	-265.244	8857.682	3562.721	0.900	1477.946	2029.561	-55.214	3206.449
96	I[138]	Max	Kuat I-2	FZ-MAX	OK	524.844	8951.184	3452.282	0.900	1477.946	2029.561	-55.225	3107.054
96	I[138]	Min	Kuat I-2	FZ-MIN	OK	-174.772	7985.367	3562.732	0.900	1477.946	2029.561	-55.225	3206.459
96	J[149]	Max	Kuat I-2	FZ-MAX	OK	550.993	7738.863	3356.007	0.900	1458.560	2002.939	-105.492	3020.406
96	J[149]	Min	Kuat I-2	FZ-MIN	OK	-148.624	8172.280	3566.991	0.900	1458.560	2002.939	-105.492	3210.292
97	I[149]	Max	Kuat I-2	FZ-MAX	OK	525.326	8354.174	3355.988	0.900	1458.560	2002.939	-105.511	3020.389
97	I[149]	Min	Kuat I-2	FZ-MIN	OK	-177.161	7353.688	3567.009	0.900	1458.560	2002.939	-105.511	3210.309
97	J[160]	Max	Kuat I-2	FZ-MAX	OK	555.772	7139.527	3238.597	0.900	1427.994	1960.965	-150.362	2914.738
97	J[160]	Min	Kuat I-2	FZ-MIN	OK	-146.714	7544.015	3539.321	0.900	1427.994	1960.965	-150.362	3185.389
98	I[160]	Max	Kuat I-2	FZ-MAX	OK	644.500	7808.988	3238.575	0.900	1427.994	1960.965	-150.384	2914.718
98	I[160]	Min	Kuat I-2	FZ-MIN	OK	-29.932	6625.112	3539.343	0.900	1427.994	1960.965	-150.384	3185.409
98	J[171]	Max	Kuat I-2	FZ-MAX	OK	679.594	6355.847	3103.627	0.900	1387.699	1905.632	-189.704	2793.264

Shear Strength Check

Elem	Part	Max/Min	LCom Name	Type	CHK	Vu (kN)	Mu (kN*m)	Vn (kN)	Phi	Vc (kN)	Vs (kN)	Vp (kN)	PhiVn (kN)
98	J[171]	Min	Ekstrem II-2	FZ-MIN	OK	5.162	6520.835	3103.627	0.900	1387.699	1905.632	-189.704	2793.264
99	I[171]	Max	Kuat I-1	MY-MAX	OK	830.846	9808.164	3103.603	0.900	1387.699	1905.632	-189.728	2793.243
99	I[171]	Min	Ekstrem II-2	FZ-MIN	OK	104.133	5525.299	3103.603	0.900	1387.699	1905.632	-189.728	2793.243
99	J[182]	Max	Kuat I-2	FZ-MAX	OK	823.678	5397.144	2956.439	0.900	1338.981	1838.730	-221.273	2660.795
99	J[182]	Min	Ekstrem II-2	FZ-MIN	OK	148.713	5290.201	2956.439	0.900	1338.981	1838.730	-221.273	2660.795
100	I[182]	Max	Kuat I-1	MY-MAX	OK	1055.502	8406.195	2956.416	0.900	1338.981	1838.730	-221.296	2660.774
100	I[182]	Min	Ekstrem II-2	FZ-MIN	OK	233.452	4316.569	2956.416	0.900	1338.981	1838.730	-221.296	2660.774
100	J[193]	Max	Kuat I-2	FZ-MAX	OK	992.833	4114.015	2801.266	0.900	1283.417	1762.428	-244.579	2521.139
100	J[193]	Min	Ekstrem II-2	FZ-MIN	OK	288.458	3898.868	2801.266	0.900	1283.417	1762.428	-244.579	2521.139
101	I[193]	Max	Kuat I-1	MY-MAX	OK	994.624	6616.831	2801.249	0.900	1283.417	1762.428	-244.596	2521.124
101	I[193]	Min	Ekstrem II-2	FZ-MIN	OK	257.812	2973.844	2801.249	0.900	1283.417	1762.428	-244.596	2521.124
101	J[204]	Max	Kuat I-1	FZ-MAX	OK	1019.300	3487.751	2639.570	0.900	1222.288	1678.484	-261.202	2375.613
101	J[204]	Min	Ekstrem II-2	FZ-MIN	OK	319.780	2490.147	2639.570	0.900	1222.288	1678.484	-261.202	2375.613
102	I[204]	Max	Kuat I-1	MY-MAX	OK	1234.549	4982.923	2639.556	0.900	1222.288	1678.484	-261.216	2375.601
102	I[204]	Min	Ekstrem II-2	FZ-MIN	OK	438.739	1675.347	2639.556	0.900	1222.288	1678.484	-261.216	2375.601
102	J[215]	Max	Kuat I-1	FZ-MAX	OK	1142.720	1113.141	2544.243	0.900	1186.513	1629.357	-271.627	2289.818
102	J[215]	Min	Ekstrem II-2	FZ-MIN	OK	507.326	812.434	2544.243	0.900	1186.513	1629.357	-271.627	2289.818
103	I[215]	Max	Kuat I-1	MY-MAX	OK	1490.720	2801.498	2544.234	0.900	1186.513	1629.357	-271.636	2289.810
103	I[215]	Min	Ekstrem II-2	FZ-MIN	OK	592.609	112.771	2544.234	0.900	1186.513	1629.357	-271.636	2289.810
103	J[226]	Max	Kuat I-1	FZ-MAX	NG	1319.051	-927.733	697.324	0.900	1186.513	1629.357	-276.253	2289.810
103	J[226]	Min	Ekstrem II-2	FZ-MIN	OK	667.479	-1075.055	697.324	0.900	1186.513	1629.357	-276.253	2289.810
104	I[226]	Max	Kuat I-1	MY-MAX	OK	1770.314	507.626	9095.716	0.900	2859.068	6517.427	-280.779	8186.144
104	I[226]	Min	Ekstrem II-2	FZ-MIN	OK	718.099	-1525.317	3270.441	0.900	2859.068	6517.427	-280.779	8186.144
104	J[6]	Max	Kuat I-1	MY-MIN	OK	1795.292	-3094.337	3271.033	0.900	2859.068	6517.427	-280.187	8186.144
104	J[6]	Min	Ekstrem II-2	FZ-MIN	OK	828.101	-3016.513	3271.033	0.900	2859.068	6517.427	-280.187	8186.144

Elem: Element number

Part: Check location (I-End, J-End) of each element

Max./Min.: Maximum shear, minimum shear

LCom. Name: Load combination name.

Type: Displays the set of member forces corresponding to moving load case or settlement load case for which the maximum stresses are produced. If it is not defined then this field is left blank(-)

CHK: Shear strength check for element

Vu: Factored shear force at section

Mu: Factored moment at section

Vn: Nominal shear resistance at section. The nominal shear resistance, Vn, shall be determined as the lesser of (refer to the clause 5.8.3.3 of AASHTO LRFD12):

Phi: Resistance factor for shear, Phi = 0.9

Vc: Nominal shear resistance of concrete. (refer to the equation 5.8.3.3-3 of AASHTO LRFD12)

Vs: Shear resistance provided by transverse (shear) reinforcement.

Vp: shear resistance component in the direction of the applied shear of the effective prestressing force. In midas Civil, shear resistance due to prestressing force, Vp, includes primary prestress force. The secondary effects from prestressing shall be included in the design shear force obtained from the load combinations.

PhiVn: Factored shear resistance. For shear strength reduction factor, Φ=0.9

Design Condition

Design Code	Element	Section	Section
AASHTO-LRFD2017	95	I	Composite

■ Section Properties

- Gross section

		Before	After
H	(mm)	2100.00	2350.00
B	(mm)	800.00	2000.00
C_{zp}	(mm)	1065.84	664.73
C_{zm}	(mm)	1034.16	1435.27
C_{zps}	(mm)		914.73
C_{zms}	(mm)		664.73
A_g	(mm²)	8.353.E+05	1.260.E+06
I_y	(mm⁴)	4.397.E+11	8.409.E+11
S_t	(mm³)	4.125.E+08	6.615.E+08
S_b	(mm³)	4.252.E+08	3.064.E+08
S_{ts}	(mm³)		9.193.E+08
S_{bs}	(mm³)		1.265.E+09

- Transformed section

		Before	After
H	(mm)	2100.00	2350.00
B	(mm)	800.00	2000.00
C_{zp}	(mm)	1094.93	692.92
C_{zm}	(mm)	1005.07	1407.08
C_{zps}	(mm)		942.92
C_{zms}	(mm)		692.92
A_g	(mm²)	8.632.E+05	1.287.E+06
I_y	(mm⁴)	4.617.E+11	8.872.E+11
S_t	(mm³)	4.216.E+08	6.663.E+08
S_b	(mm³)	4.593.E+08	3.281.E+08
S_{ts}	(mm³)		8.918.E+08
S_{bs}	(mm³)		1.214.E+09

■ Materials

- Concrete

	f'_c (MPa)	E_c (MPa)	$f_r=0.20\sqrt{f'_c}$ (MPa)	β_1
Girder	50.000	4786.2	4.456	0.687
Slab	30.000	4061.1	3.452	0.832

* β_1 : 0.85 if f'c is lower than 4ksi, the others are 0.85-0.05(f'c-4.0)≥0.65

- Prestressing steel information

No.	Tendon	Bond Type	d_p (mm)	A_{ps} (mm²)	Strength (MPa) f_{py}	Strength (MPa) f_{pu}	E_p (MPa)
1	S_G3 - T1	Bond	2150.000	1875.490	1674.000	1860.000	196500.644
2	S_G3 - T2	Bond	2250.000	1875.490	1674.000	1860.000	196500.644
3	S_G3 - T3	Bond	2250.000	1875.490	1674.000	1860.000	196500.644

* d_p : Distance from extreme compression fiber to centroid of prestressing tendon.

- Longitudinal non prestressed steel reinforcement information

Girder		Slab		Bottom for Flexure		Top for Flexure		Torsion
Es (MPa)	fy (MPa)	Es (MPa)	fy (MPa)	ds (mm)	As (mm²)	ds (mm)	As (mm²)	A_l (mm²)
199948.0	413.69	199948.0	413.69	0.00	0.00	0.00	0.00	0.00

* d_s || d'_s : Distance from extreme compression fiber to centroid of non prestressing reinforcement.

- Transverse non prestressed steel reinforcement information

			Shear		Torsion	
E_s (MPa)	f_y (MPa)	α (deg.)	A_v (mm²)	s (mm)	A_t (mm²)	s_t (mm)
199948.0	413.686	90.000	258.064	200.000	0.000	0.000

* α : Angle between longitudinal and stirrup.

■ **Sectional forces/stresses due to effective prestress**

No.	Tendon Name	Bond Type	e_p (mm)	$A_{ps}f_{e(z-dir)}$ (kN)	$A_{ps}f_{e(x-dir)}$ (kN)	$A_{ps}f_{e(x-dir)}e_p$ (kN·m)
1	S_G3 - T1	Bond	-1207.078	0.000	1913.108	2309.271
2	S_G3 - T2	Bond	-1307.078	0.000	1924.041	2514.872
3	S_G3 - T3	Bond	-1307.078	0.000	1934.843	2528.991
			Σ	0.000	5771.992	7353.134

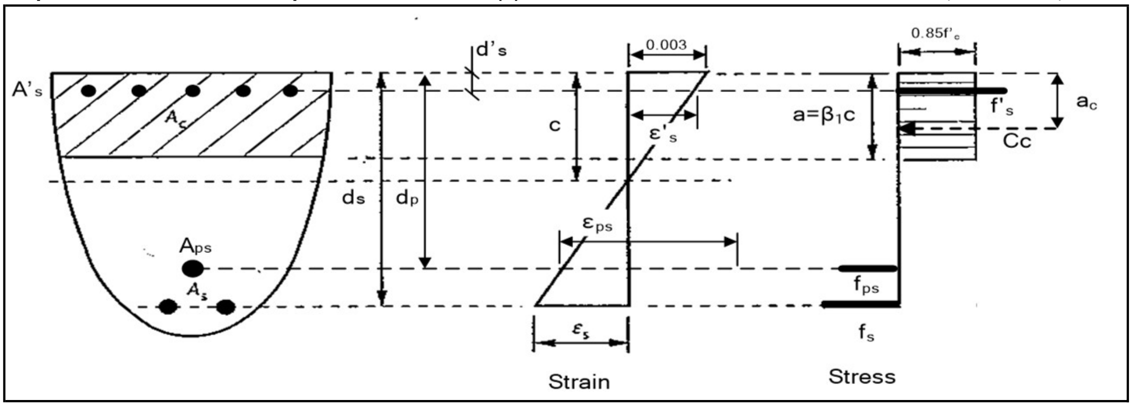
* e_p : Distance from centroid of section to centroid of tendon

2.Flexure design for a section

■ **Moment Direction** **Positive**

- Method of Calculation : Code
- The maximum strength limit load combination : Kuat I-1
- The maximum factored moment (M_u) : 12646.240 (kN·m)

1) Depth of neutral axis to compression face (c). *(See 5.6.3.1)*



Axial force in concrete (compressive zone):					
c	$a=\beta_1 c$	A_c	a_c	$C_c = 0.85\ f'_c A_c$	$C_c(c-a_c)$
239.246	199.158	398316.880	99.579	10157.080	1418.603

Axial force in reinforcement steels			
tensile zone		compressive zone	
$T_s=A_sf_s$	$\Sigma A_sf_s(d_s-c)$	$C_s=A'_sf'_s$	$\Sigma A'_sf'_s(c-d'_s)$
0.000	0.000	0.000	0.000

No.	Axial force in tendons(Bond) by Code				
	Tendon Name	k	f_{ps}	$T_{ps}=A_{ps}f_{ps}$	$A_{ps}f_{ps}(d_p-c)$
1	S_G3 - T1	0.280	1802.047	3379.721	6457.817
2	S_G3 - T2	0.280	1804.623	3384.552	6805.502
3	S_G3 - T3	0.280	1804.623	3384.552	6805.502
			Σ	10148.824	20068.821

* $f_{ps} = f_{pu}(1-k\ c/d_p)$ $k = 2(1.04-f_{py}/f_{pu})$

c (mm)	Compression Force (kN)		Tensile Force (kN)		Tolerance
	C_c	C_s	T_s	T_{ps}	(C/T)
239.246	10157.080	0.000	0.000	10148.824	1.00081

2) Flexural resistance

- Nominal resistance (Mn). *(See 5.6.3.2)*

  $M_n = \Sigma A_s f_s(d_s\text{-}c)+\Sigma A_{ps}f_{ps}(d_p\text{-}c)+C_c(c\text{-}a_c)+\Sigma A'_s f'_s(c\text{-}d'_s) =$ 21487.42 (kN·m)

- Resistance factor (Φ).

  d_t = 2250.000 (mm)

  $\varepsilon_t = 0.003(d_t/c\text{-}1)$ = 0.0252 : Net tensile strain in the extreme tension steel

∴ Φ = 1.00 : Tension Controlled Range, $0.005 \leq \varepsilon_t$

- Factored resistance ($M_r = \Phi M_n$)

  M_r = 21487.424 (kN·m) ≥ M_u = 12646.24 (kN·m) **OK**

3) Minimum reinforcement

- IDS_CVL_RPT_US_133MU : 미등록 문자열 *(See 5.6.3.3)*

  M_r = 21487.424 (kN·m) ≥ $1.33M_u$ = 16819.50 (kN·m)

- Cracking moment (M_{cr}) *(Eq. 5.7.3.3.2-1)*

  $M_{cr} = \gamma_3 [(\gamma_1 \cdot f_r + \gamma_2 \cdot f_{cpe})S_c - M_{dnc}(S_c/S_{nc}-1)]$ = 11918.13 (kN·m)

  Where,

M_{dnc}	=	6.444.E+03 (kN·m)	:	*Non-Composite dead load moment*
S_c	=	5.859.E+08 (mm³)	:	*Composite Section Modulus for extreme fiber*
S_{nc}	=	4.252.E+08 (mm³)	:	*Non-Composite Section Modulus for extreme fiber*
γ_1	=	1.200	:	*Flexural cracking variability factor*
γ_2	=	1.100	:	*Prestress variability factor*
γ_3	=	1.000	:	*Ratio of yield strength to ultimate tensile strength of the reinforcement*

  f_{cpe} = *Compressive stress in concrete due to effective prestress only*

  $= \Sigma A_{ps} \cdot f_{e(x\text{-}dir)} / A_g + \Sigma A_{ps} \cdot f_{e(x\text{-}dir)} \cdot e_p / S_b$ = 17.41 (kN)

- Checking minimum reinforcement

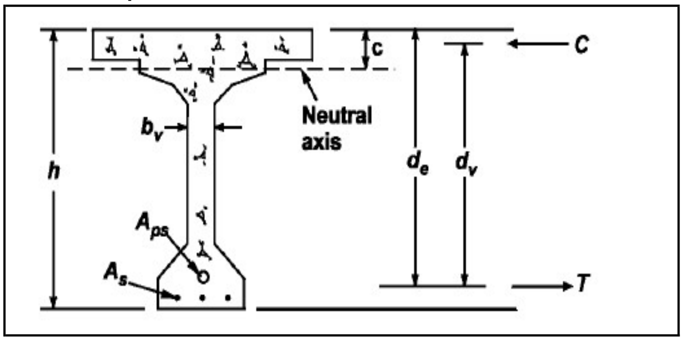
  M_r = 21487.42 (kN·m) ≥ M_{cr} = 11918.13 (kN·m) **OK**

3.Shear design for a section

■ Maximum Shear

- Section type : Segmental-Solid
- The Strength Limit Load Combination : Kuat I-2
- Factored shear force : V_u = 384.80 (kN) (including Vp)
- Factored moment : M_u = 9162.72 (kN·m)
- Factored axial force : N_u = -5790.57 (kN)
- Resistance factor for shear : Φ = 0.90
- Component of prestressing force in direction of the shear force $V_p = \Sigma A_{ps} \cdot f_{e(z\text{-}dir)}$ = 0.00 (kN)

1) Effective depth



b_v = 249.00 (mm) Effective web width

$$d_e = \frac{A_{ps}f_{ps}d_p + A_sf_sd_s}{A_{ps}f_{ps} + A_sf_s} = 2216.698 \text{ (mm)}$$ Effective depth for bending

$$d_v = \text{Max}\left[\frac{M_n}{A_{ps}f_{ps} + A_sf_s},\ 0.9d_e,\ 0.72h\right]$$ Effective depth for shear

= Max [2117.233 , 1995.029 , 1692.000]

= 2117.233 (mm)

2) Maximum Spacing for transverse reinforcement **(s_{max})**

- Shear stress on concrete (v_u).

$$v_u = \frac{|V_u - \Phi V_p|}{\Phi b_v d_v} = 0.811 \text{ (MPa)}$$ *(Eq. 5.7.2.8-1)*

- Maximum Spacing for transverse reinforcement (s_{max})

v_u = 0.811 (MPa) < $0.125 \cdot f'_c$ = 6.250 (MPa)

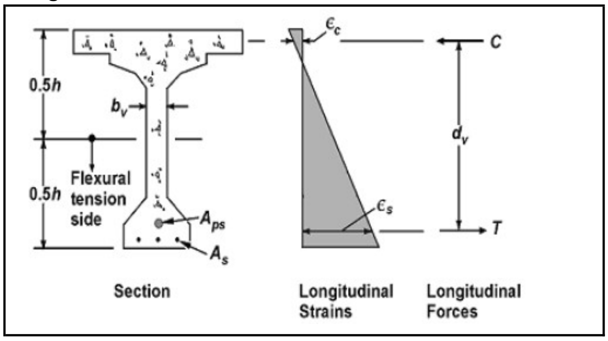
∴ s_{max} = Min[$0.8d_v$, 24.0(in.)] = 609.600 (mm) *(Eq. 5.7.2.6-1)*

∴ s = 200.000 (mm) ≤ s_{max} **OK**

3) Minimum required transverse reinforcement **($A_{v,min}$)**

- Need Not Check

4) Longitudinal Strain **(ε_s)**



$$\varepsilon_s = \frac{(|M_u|/d_v + 0.5N_u + |V_u - V_p| - A_{ps}f_{po})}{E_sA_s + E_pA_{ps}} = -0.0050 \quad , \quad 0.0 \le \varepsilon_s \le 0.006$$ *(Eq. 5.7.3.4.2-4)*

∴ ε_s = 0.0000

where, $|M_u|$ = Max [M_u , $|V_u-V_p|d_v$] = Max [9162.719 , 814.709]

= 9162.719 (kN·m)

f_{po} = $0.7f_{pu}$ = 1302.000 (MPa)

5) Component of shear resisted by tensile stresses in concrete **(V_c)**

- Factor indicating diagonally cracked concrete to transmit tension (β).

$$\beta = \frac{4.8}{(1+750\varepsilon_s)} = 4.800 \quad \because A_v \geq A_{v,min}$$ *(Eq. 5.7.3.4.2-1)*

- Nominal shear resistance provide by concrete

V_c = $0.0316\ \beta \sqrt{f'_c}\, b_v d_v$ = 1484.707 (kN) *(Eq. 5.7.3.3-3)*

6) Component of shear resisted by transverse reinforcement **(V_s)**

- Area of transverse reinforcement required *(See 5.8.2.4)*

$0.5\Phi(V_c+V_p)$	$\Phi(V_c+V_p)$	V_u
668.12 (kN)	1336.24 (kN)	384.80 (kN)

$V_u < 0.5\Phi(V_c+V_p)$ ∴ No Shear reinforcing

- Component of shear resisted by transverse reinforcement (V_s)

$$V_s = \frac{A_v \cdot f_y \cdot d_v(\cot\theta + \cot\alpha)\sin\alpha}{s} = 2038.846 \text{ (kN)}$$ *(Eq. 5.7.3.3-4)*

Where, $\theta = 29+3500\varepsilon_s$ = 29.000 (deg.) *(Eq. 5.7.3.4.2-3)*

α = 90.000 (deg.)

7) Shear resistance

- Nominal shear strength *(Eq. 5.7.3.3-1)*

$V_c+V_s+V_p$ = 3523.553 (kN) ≤ $0.25 \cdot f'_c b_v d_v + V_p$ = 6589.887 (kN)

∴ V_n = $V_c+V_s+V_p$ = 3523.553 (kN)

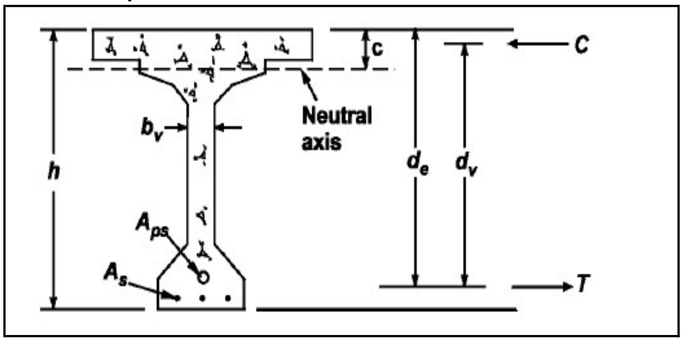
- Factored shear resistance (V_r).

∴ V_r = ΦV_n = 3171.198 (kN) ≥ V_u = 384.799 (kN) **OK**

■ Minimum Shear

- Section type : Segmental-Solid
- The Strength Limit Load Combination : Kuat I-2
- Factored shear force : V_u = -287.46 (kN) (including Vp)
- Factored moment : M_u = 8442.61 (kN·m)
- Factored axial force : N_u = -5788.88 (kN)
- Resistance factor for shear : Φ = 0.90
- Component of prestressing force in direction of the shear force $V_p = \Sigma A_{ps} \cdot f_{e(z\text{-}dir)}$ = 0.00 (kN)

1) Effective depth



b_v = 249.00 (mm) Effective web width

$d_e = \dfrac{A_{ps}f_{ps}d_p + A_sf_sd_s}{A_{ps}f_{ps} + A_sf_s}$ = 2216.698 (mm) Effective depth for bending

d_v = Max [$\dfrac{M_n}{A_{ps}f_{ps} + A_sf_s}$, $0.9d_e$, $0.72h$] Effective depth for shear

= Max [2117.233 , 1995.029 , 1692.000]

= 2117.233 (mm)

2) Maximum Spacing for transverse reinforcement **(s_{max})**

- Shear stress on concrete (v_u).

$v_u = \dfrac{| V_u - \Phi V_p |}{\Phi b_v d_v}$ = 0.606 (MPa) *(Eq. 5.7.2.8-1)*

- Maximum Spacing for transverse reinforcement (s_{max})

v_u = 0.606 (MPa) < $0.125 \cdot f'_c$ = 6.250 (MPa)

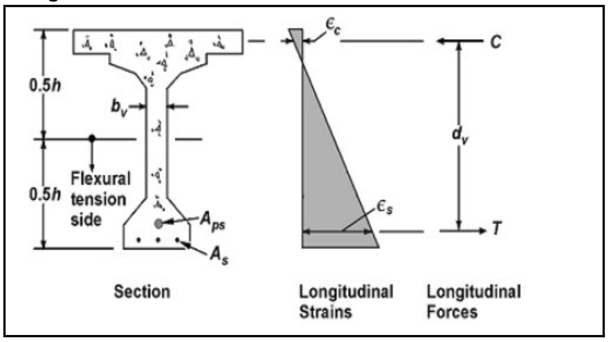
∴ s_{max} = Min[$0.8d_v$, 24.0(in.)] = 609.600 (mm) *(Eq. 5.7.2.6-1)*

∴ s = 200.000 (mm) ≤ s_{max} **OK**

3) Minimum required transverse reinforcement **($A_{v,min}$)**

- Need Not Check

4) Longitudinal Strain **(ε_s)**



$\varepsilon_s = \dfrac{(|M_u|/d_v + 0.5N_u + |V_u - V_p| - A_{ps}f_{po})}{E_sA_s + E_pA_{ps}}$ = -0.0054 , $0.0 \le \varepsilon_s \le 0.006$ *(Eq. 5.7.3.4.2-4)*

∴ ε_s = 0.0000

where, $|M_u|$ = Max [M_u , $|V_u - V_p| d_v$] = Max [8442.611 , 608.627]

= 8442.611 (kN·m)

f_{po} = $0.7f_{pu}$ = 1302.000 (MPa)

5) Component of shear resisted by tensile stresses in concrete **(V_c)**

- Factor indicating diagonally cracked concrete to transmit tension (β).

$\beta = \dfrac{4.8}{(1+750\varepsilon_s)}$ = 4.800 ∵ $A_v \ge A_{v,min}$ *(Eq. 5.7.3.4.2-1)*

- Nominal shear resistance provide by concrete

V_c = $0.0316\, \beta \sqrt{f'_c}\, b_v d_v$ = 1484.707 (kN) *(Eq. 5.7.3.3-3)*

6) Component of shear resisted by transverse reinforcement **(V_s)**

- Area of transverse reinforcement required *(See 5.8.2.4)*

$0.5\Phi(V_c+V_p)$	$\Phi(V_c+V_p)$	V_u
668.12 (kN)	1336.24 (kN)	287.46 (kN)

$V_u < 0.5\Phi(V_c+V_p)$ ∴ No Shear reinforcing

- Component of shear resisted by transverse reinforcement (V_s)

$$V_s = \frac{A_v \cdot f_y \cdot d_v(\cot\theta+\cot\alpha)\sin\alpha}{s} = 2038.846 \text{ (kN)}$$ *(Eq. 5.7.3.3-4)*

Where, $\theta = 29+3500\varepsilon_s = 29.000$ (deg.) *(Eq. 5.7.3.4.2-3)*

$\alpha = 90.000$ (deg.)

7) Shear resistance

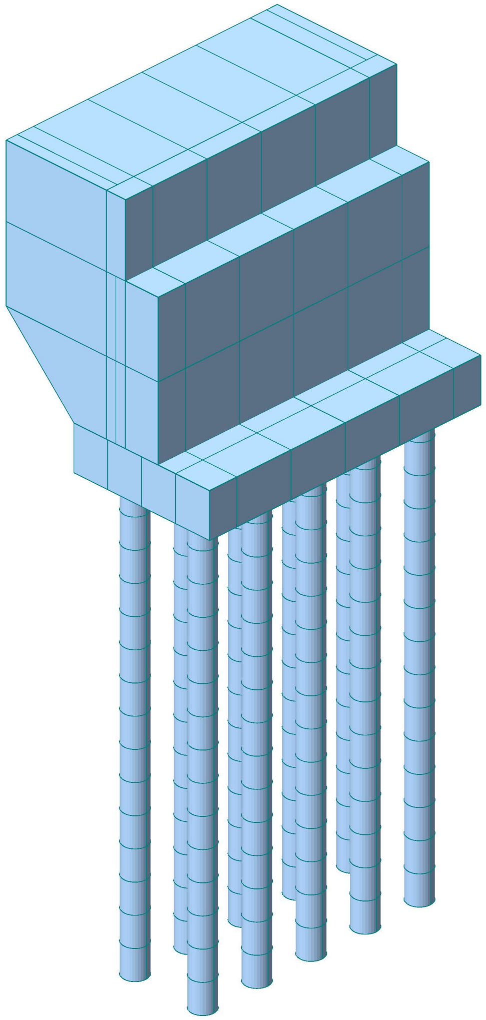
- Nominal shear strength *(Eq. 5.7.3.3-1)*

$V_c+V_s+V_p = 3523.553$ (kN) $\leq 0.25 \cdot f'_c b_v d_v + V_p = 6589.887$ (kN)

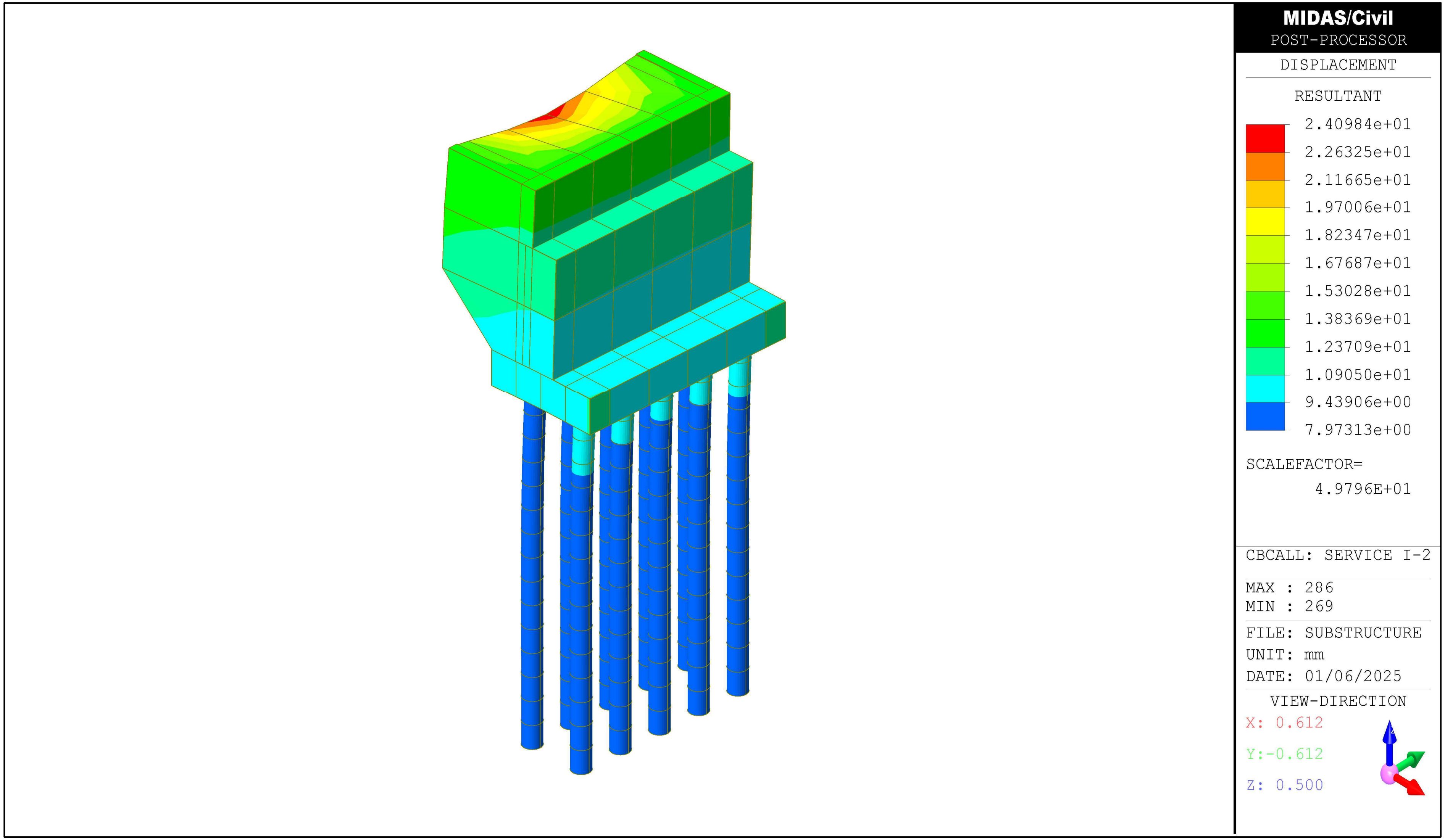
∴ $V_n = V_c+V_s+V_p = 3523.553$ (kN)

- Factored shear resistance (V_r).

∴ $V_r = \Phi V_n = |3171.198|$ (kN) $\geq V_u = |-287.463|$ (kN) **OK**



3D-View of Bridge Substructure and Foundation

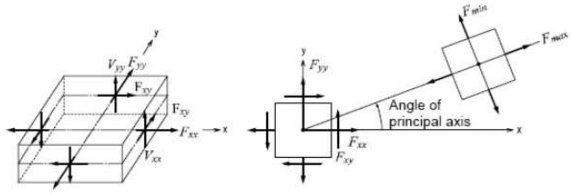


Bridge Substructure and Foundation Deformation

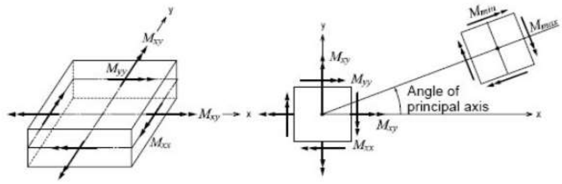
Eigenvalue Mode

Mode	UX		UY		UZ		RX		RY		RZ	
EIGENVALUE ANALYSIS												
Mode No	Frequency (rad/sec)		Frequency (cycle/sec)		Period (sec)		Tolerance					
1	7.15268		1.13838		0.87844		0.000E+00					
2	7.24231		1.15265		0.86757		0.000E+00					
3	11.78808		1.87613		0.53301		0.000E+00					
4	17.40531		2.77014		0.36099		0.000E+00					
5	21.48306		3.41914		0.29247		0.000E+00					
6	66.01087		10.50596		0.09518		0.000E+00					
7	70.48417		11.21790		0.08914		0.000E+00					
8	80.71461		12.84613		0.07784		0.000E+00					
9	131.72099		20.96405		0.04770		1.626E-65					
10	137.94103		21.95400		0.04555		2.072E-61					
11	142.29818		22.64746		0.04416		8.658E-60					
12	166.04755		26.42729		0.03784		2.430E-50					
MODAL PARTICIPATION MASSES PRINTOUT												
Mode No	TRAN-X		TRAN-Y		TRAN-Z		ROTN-X		ROTN-Y		ROTN-Z	
	MASS(%)	SUM(%)	MASS(%)	SUM(%)	MASS(%)	SUM(%)	MASS(%)	SUM(%)	MASS(%)	SUM(%)	MASS(%)	SUM(%)
1	0.00	0.00	99.98	99.98	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
2	100.00	100.00	0.00	99.98	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
3	0.00	100.00	0.00	99.98	0.00	0.00	0.00	0.01	0.00	0.00	99.99	99.99
4	0.00	100.00	0.00	99.98	77.60	77.60	0.00	0.01	0.00	0.00	0.00	99.99
5	0.00	100.00	0.01	99.99	0.00	77.60	77.76	77.77	0.00	0.00	0.00	99.99
6	0.00	100.00	0.00	99.99	0.00	77.60	0.00	77.77	55.69	55.69	0.00	99.99
7	0.00	100.00	0.00	99.99	0.00	77.60	0.00	77.77	0.00	55.69	0.00	100.00
8	0.00	100.00	0.01	100.00	0.00	77.60	0.06	77.83	0.00	55.69	0.00	100.00
9	0.00	100.00	0.00	100.00	0.00	77.60	0.00	77.83	0.00	55.69	0.00	100.00
10	0.00	100.00	0.00	100.00	10.09	87.69	0.00	77.83	0.00	55.69	0.00	100.00
11	0.00	100.00	0.00	100.00	0.00	87.69	10.16	87.99	0.00	55.69	0.00	100.00
12	0.00	100.00	0.00	100.00	0.00	87.69	0.00	87.99	0.00	55.69	0.00	100.00
Mode No	TRAN-X		TRAN-Y		TRAN-Z		ROTN-X		ROTN-Y		ROTN-Z	
	MASS	SUM	MASS	SUM	MASS	SUM	MASS	SUM	MASS	SUM	MASS	SUM
1	0	0	731.91	731.91	0	0	0.48	0.48	0	0	0	0
2	732.08	732.08	0	731.91	0	0	0	0.48	0.81	0.81	0	0
3	0	732.08	0	731.91	0	0	0	0.48	0	0.81	111633.32	111633.32
4	0	732.08	0	731.91	568.06	568.06	0	0.48	0	0.81	0	111633.32
5	0	732.08	0.07	731.98	0	568.06	4491.71	4492.19	0	0.81	0	111633.32
6	0.01	732.08	0	731.98	0	568.06	0	4492.19	58949.99	58950.8	0	111633.32
7	0	732.08	0	731.98	0	568.06	0	4492.19	0.01	58950.81	1.87	111635.19
8	0	732.08	0.1	732.08	0	568.06	3.71	4495.9	0	58950.81	0	111635.19
9	0	732.08	0	732.08	0	568.06	0	4495.9	0	58950.81	3.15	111638.34
10	0	732.08	0	732.08	73.88	641.94	0	4495.9	0	58950.81	0	111638.34
11	0	732.08	0	732.08	0	641.94	586.7	5082.6	0	58950.81	0	111638.34
12	0	732.08	0	732.08	0	641.94	0	5082.6	0	58950.81	0	111638.34

INTERNAL FORCE PER UNIT LENGTH OF SUBSTRUCTURE								
	Fxx (kN/m)	Fyy (kN/m)	Fxy (kN/m)	Mxx (kN*m/m)	Myy (kN*m/m)	Mxy (kN*m/m)	Vxx (kN/m)	Vyy (kN/m)
Breast wall								
MAX	428.043	580.777	816.057	192.998	699.099	148.108	316.681	261.468
MIN	-325.934	-1595.589	-253.993	-332.053	-191.004	-74.736	-307.689	-108.269
Back Wall								
MAX	589.822	194.898	137.829	64.752	360.989	55.647	63.321	241.336
MIN	-453.462	-258.169	-89.232	-82.288	-174.796	-55.647	3.157	-241.336
Wing Wall								
MAX	258.827	546.766	416.995	70.98	132.427	94.541	82.301	61.36
MIN	-260.178	-992.014	-378.991	-123.109	-69.643	-94.541	-72.723	-110.527
Approch Slab								
MAX	68.784	248.69	60.632	26.461	60.807	49.305	82.301	61.36
MIN	-46.254	-214.945	-49.788	-70.227	-79.311	-49.305	-72.723	-110.527
Pile Cap								
MAX	248.285	389.812	353.046	70.98	332.427	94.541	82.301	61.36
MIN	-471.7	-307.822	-148.539	-133.109	-69.643	-94.541	-72.723	-110.527

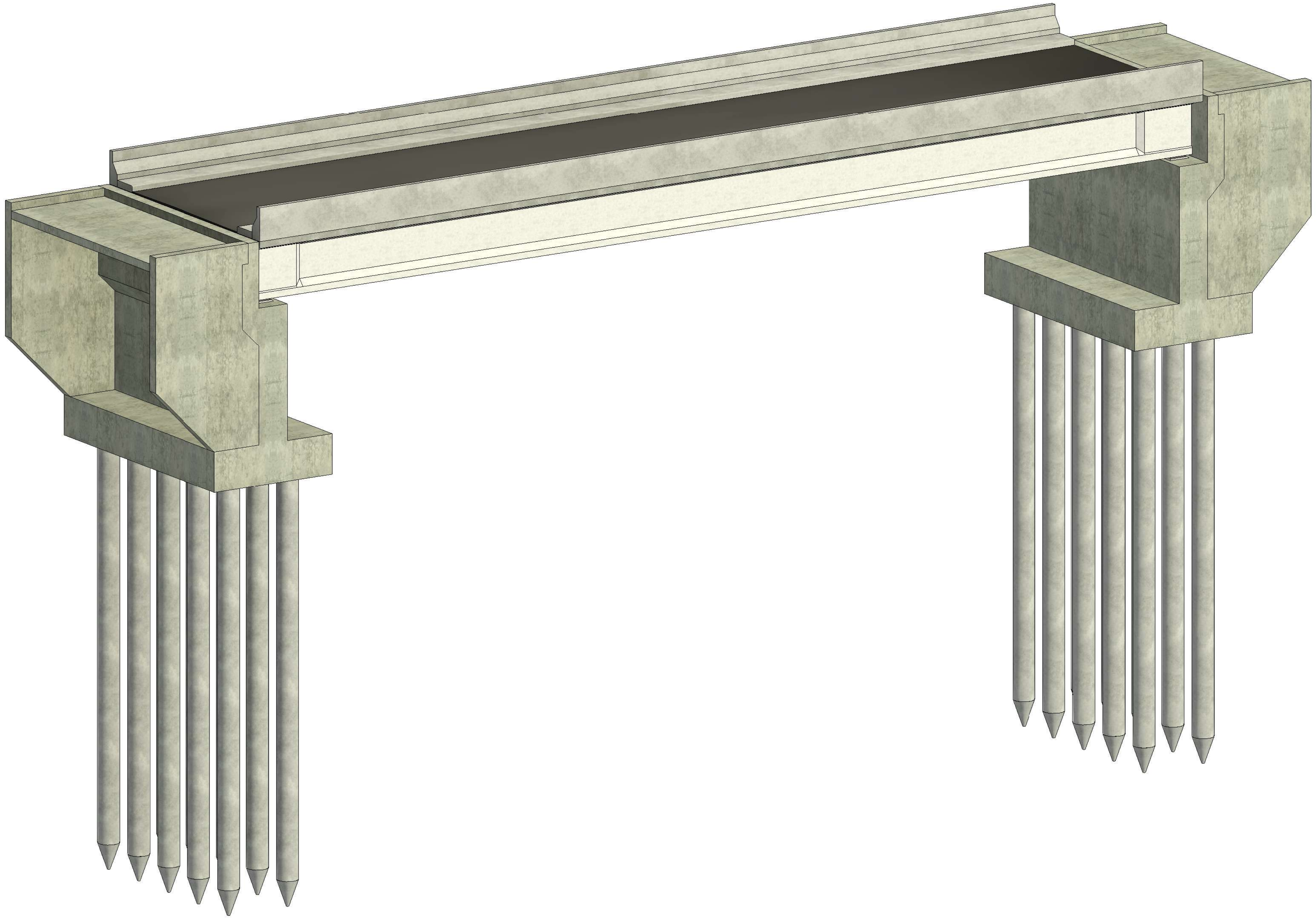


(a) Force per unit length due to in-plane actions at the output locations



(b) Moments per unit length due to out-of plane bending actions at the output locations

INTERNAL FORCE OF PILE FOUNDATION						
	Axial (kN)	Shear-x (kN)	Shear-y (kN)	Torsion (kN*m)	Moment-x (kN*m)	Moment-y (kN*m)
Pile						
MAX	1233.24	574.68	198.79	0	714.75	857.36
MIN	-1886.38	-15.32	-113.94	0	-364.46	-63.22



3D Structure

DEPARTMENT OF CIVIL ENGINEERING
FACULTY OF ENGINEERING
ANDALAS UNIVERSITY
PADANG
2024

LEGEND

CHECKED BY

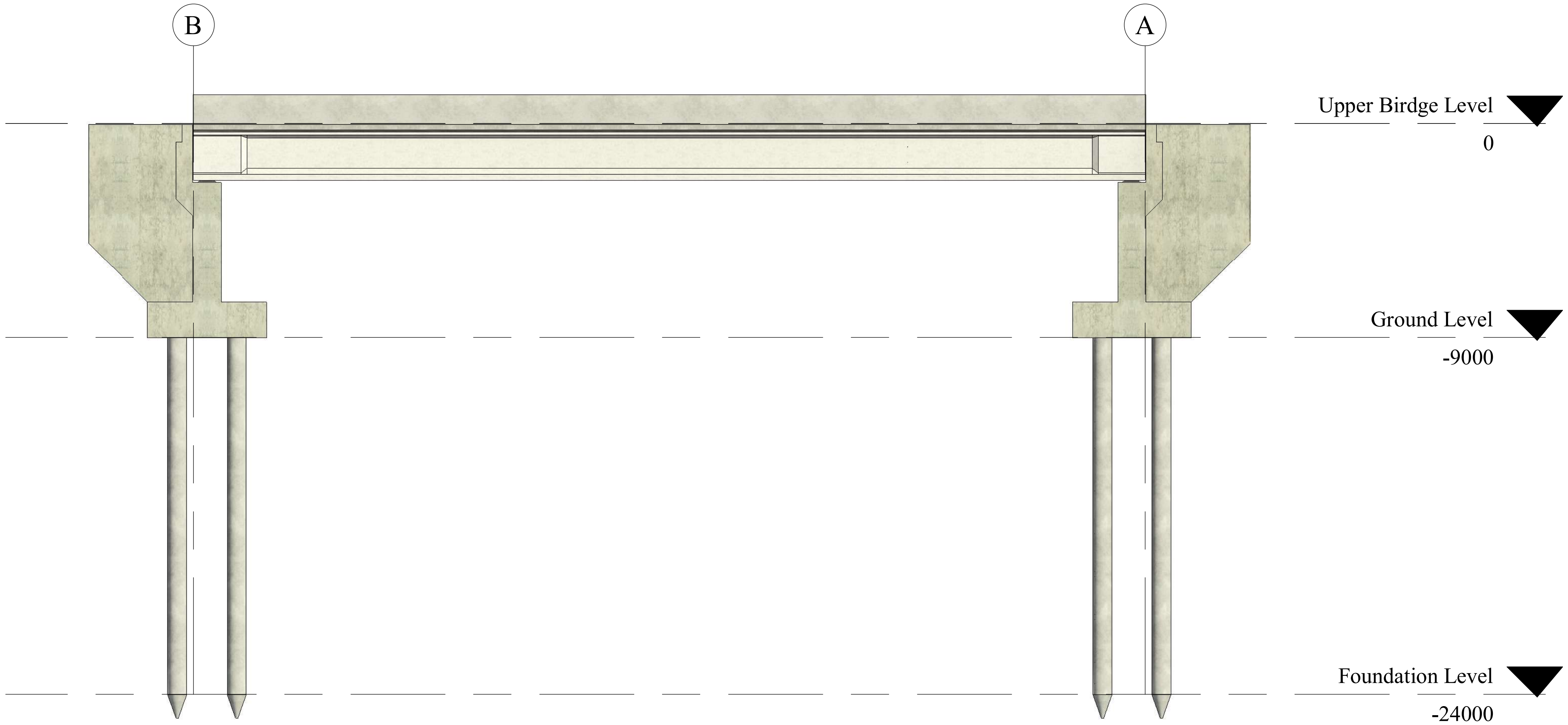
MASRILAYANTI, S.T, M.Sc, Ph.d
NIP . 197512192001122001

PROJECT

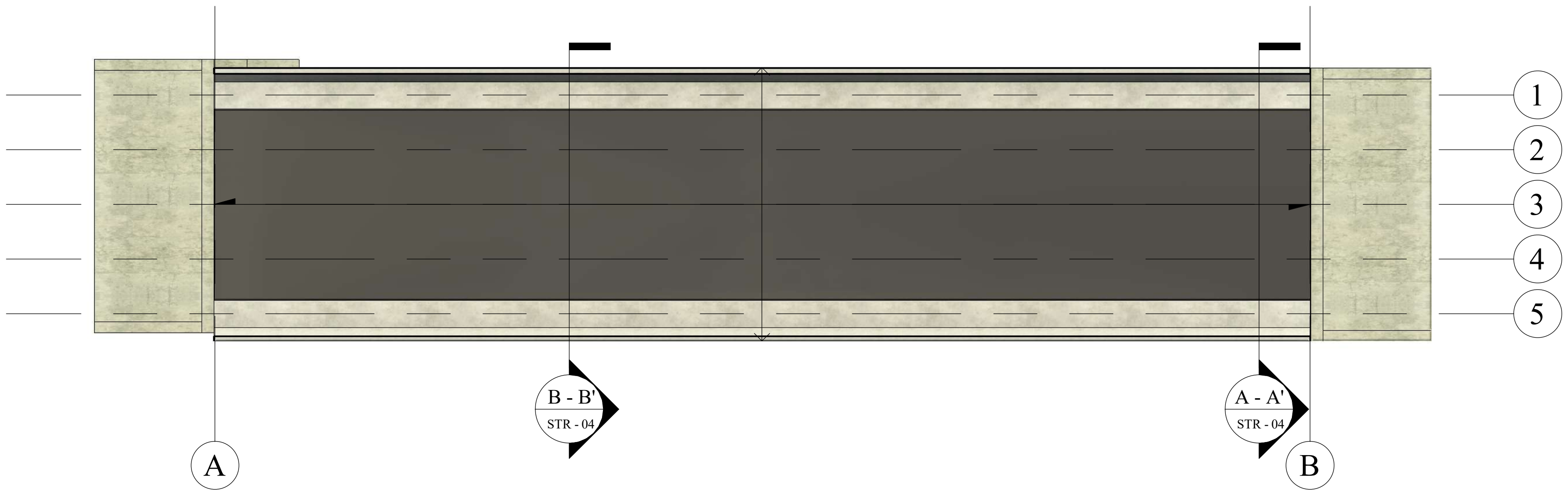
PRESTRESSED CONCRETE BRIDGE

DESIGN BY	AFDHIL
ID NUMBER	2110922064

PROJECT TITLE	SCALE
3D Structure	NTS
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : STR - 01	1 / 8
DATE :	



Side View
1 : 250



Top View
1 : 250

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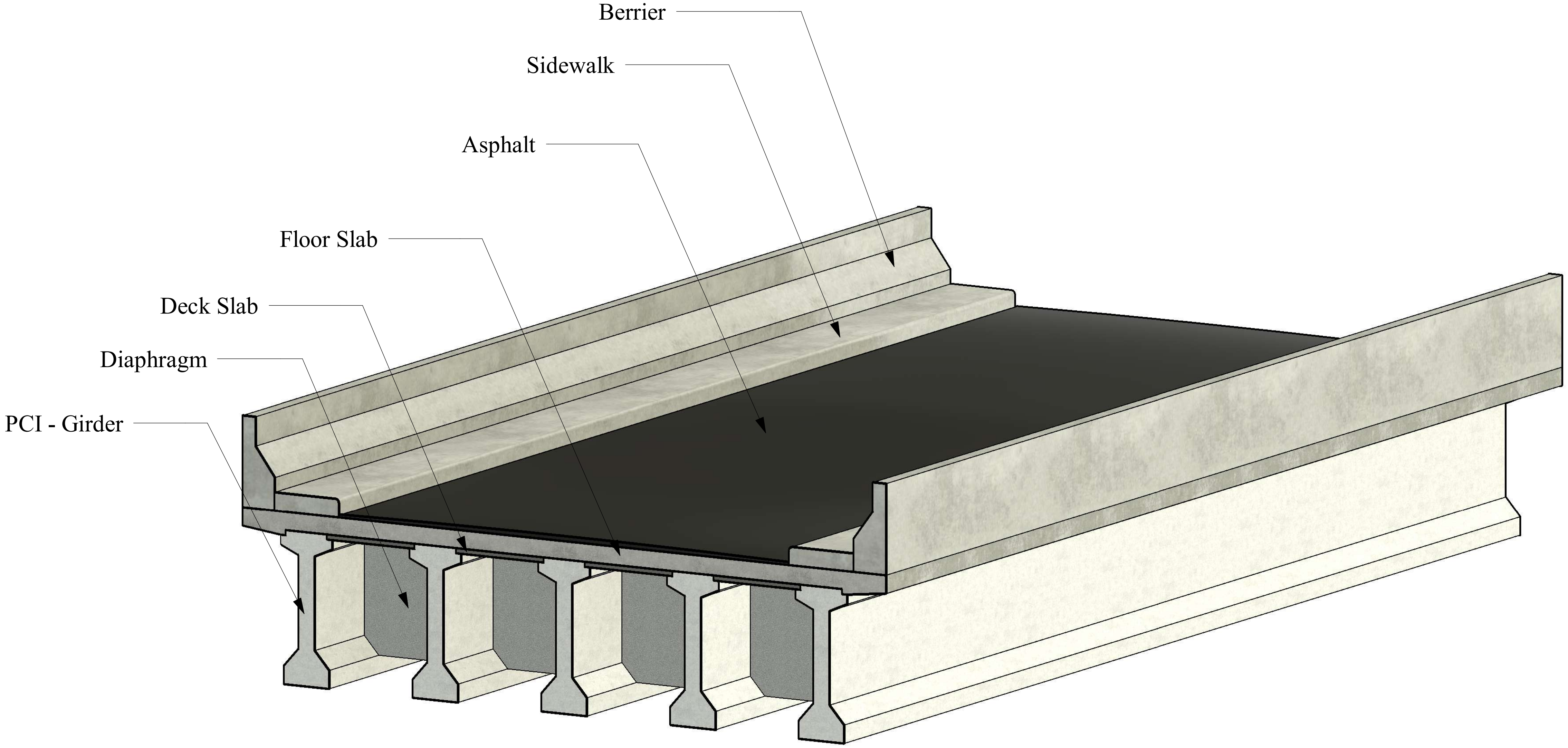
NIP . 197512192001122001

PROJECT

PRESTRESSED CONCRETE BRIDGE

DESIGN BY	AFDHIL
ID NUMBER	2110922064

PROJECT TITLE	SCALE
Layout View	1 : 250
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : STR - 02	2 / 8
DATE :	



3D Modeling of Bridge Superstructure

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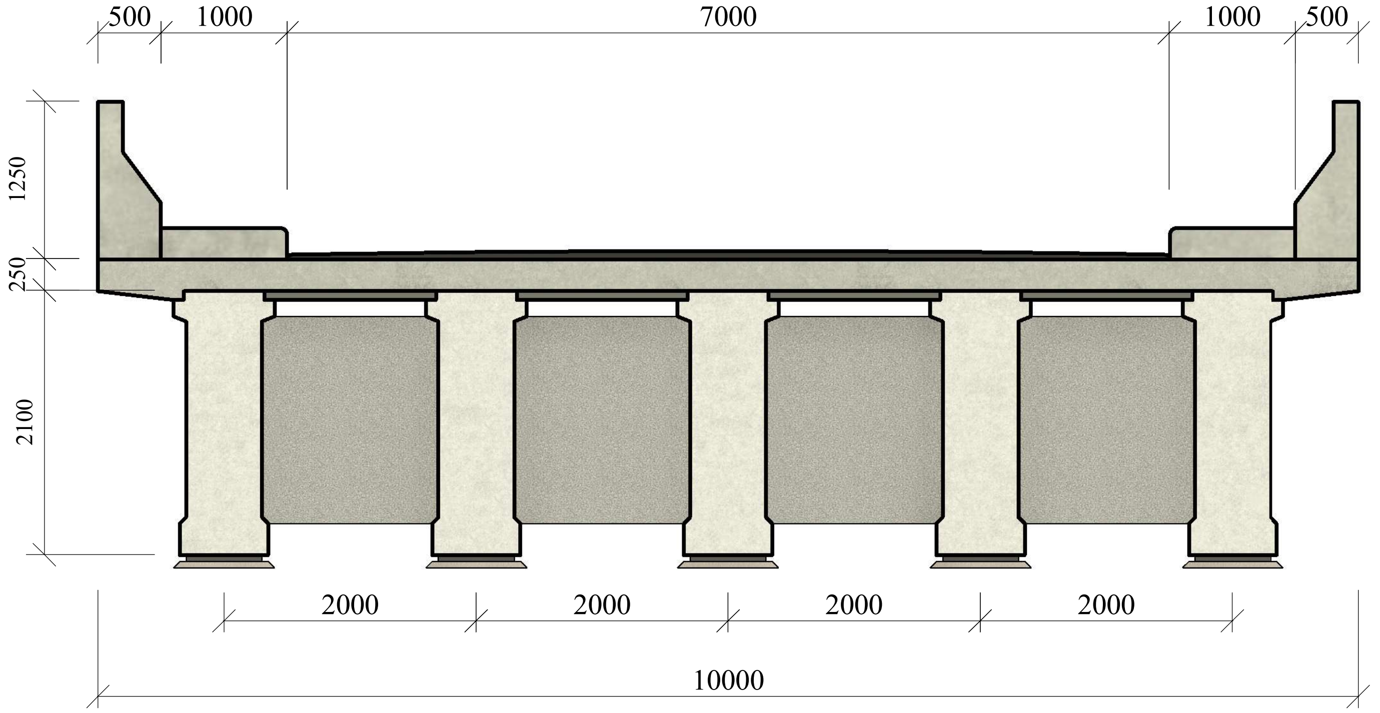
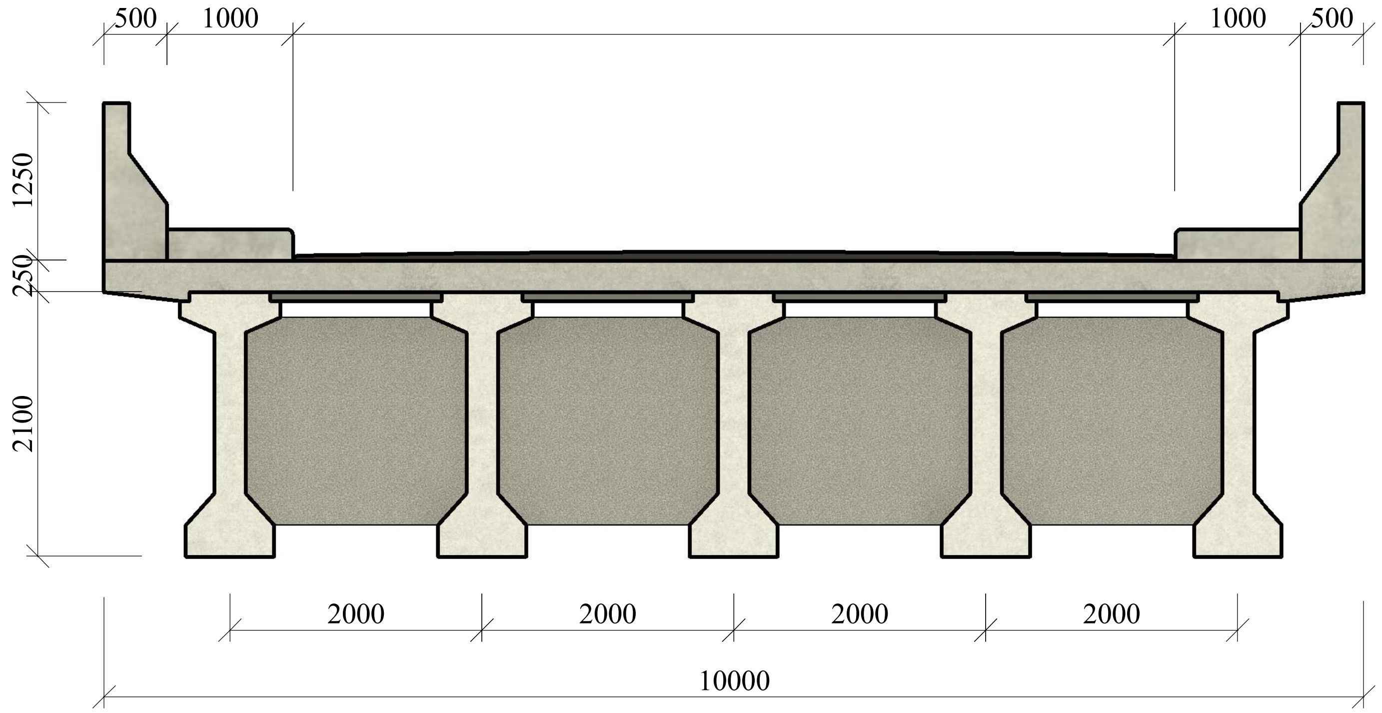
PROJECT	
PRESTRESSED CONCRETE BRIDGE	
DESIGN BY	AFDHIL
ID NUMBER	2110922064

PROJECT TITLE	SCALE
3D Modeling of Bridge Superstructure	
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : STR - 03	3 / 8
DATE :	



A - A' Section

1 : 60



B - B' Section

1 : 60

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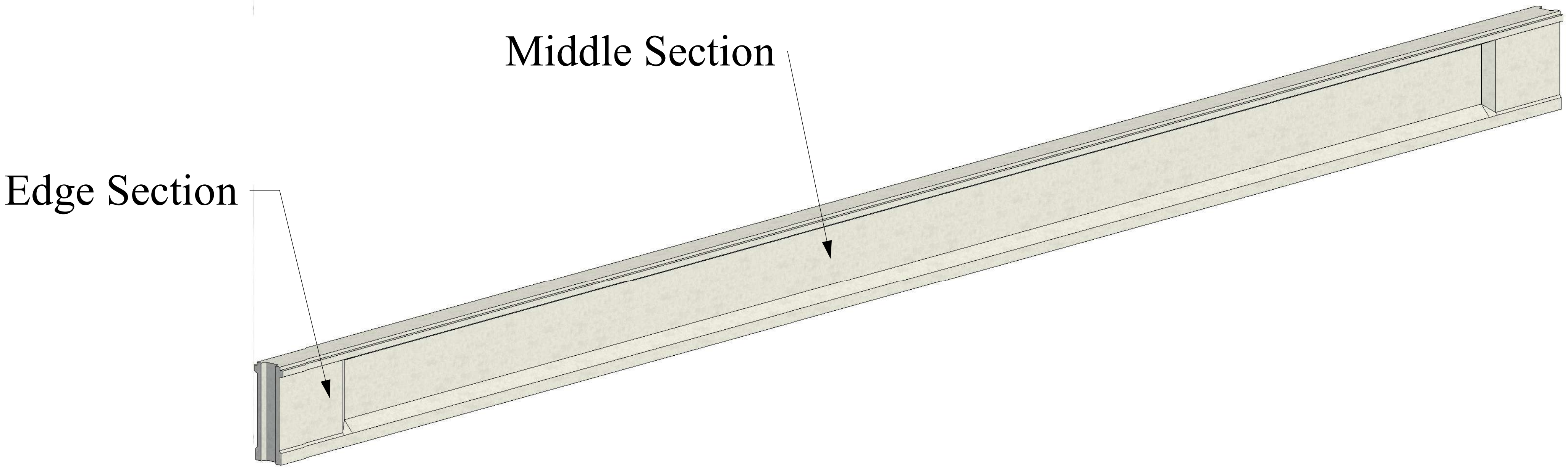
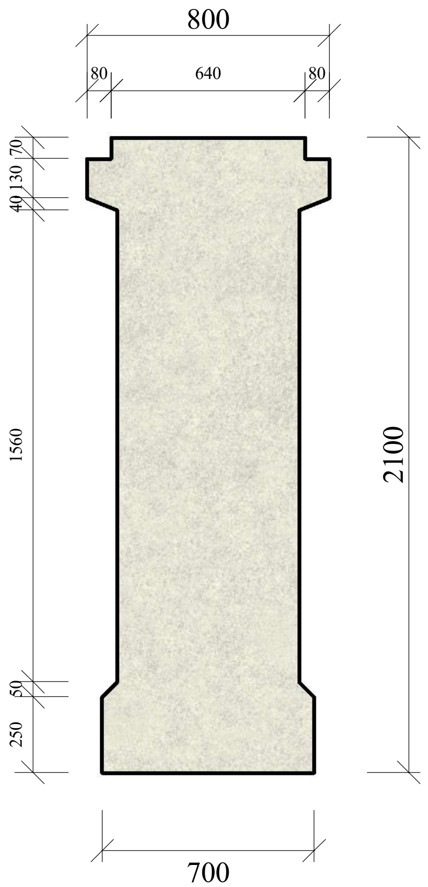
PROJECT	
PRESTRESSED CONCRETE BRIDGE	
DESIGN BY	AFDHIL
ID NUMBER	2110922064

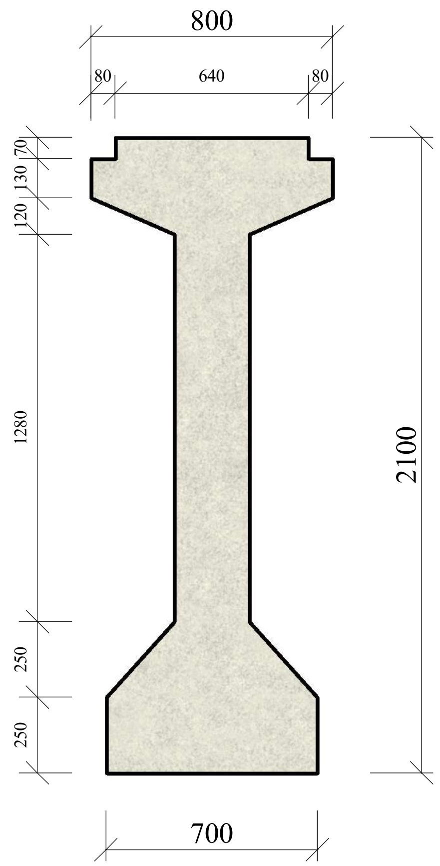
PROJECT TITLE	SCALE
Cross - Section View	1 : 60
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : STR - 04	4 / 8
DATE :	



3D Modeling of PCI-Girder



Edge Section of PCI-Girder
1 : 25



Middle Section of PCI-Girder
1 : 25

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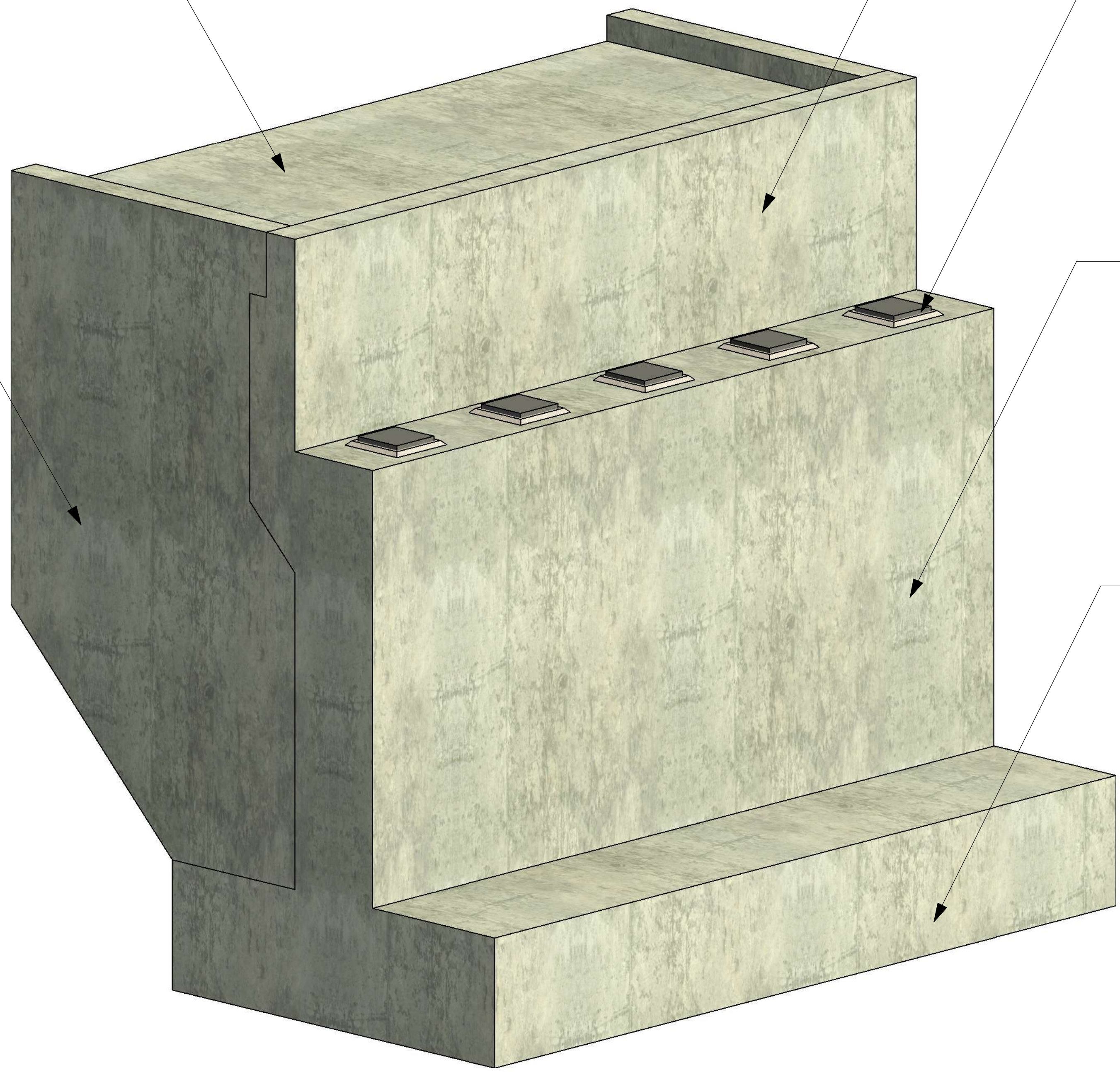
NIP . 197512192001122001

PROJECT	
PRESTRESSED CONCRETE BRIDGE	
DESIGN BY	AFDHIL
ID NUMBER	2110922064

PROJECT TITLE	SCALE
Dimension of PCI Girder	1 : 25
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : STR - 05	5 / 8
DATE :	



3D Modeling of Bridge Substructure

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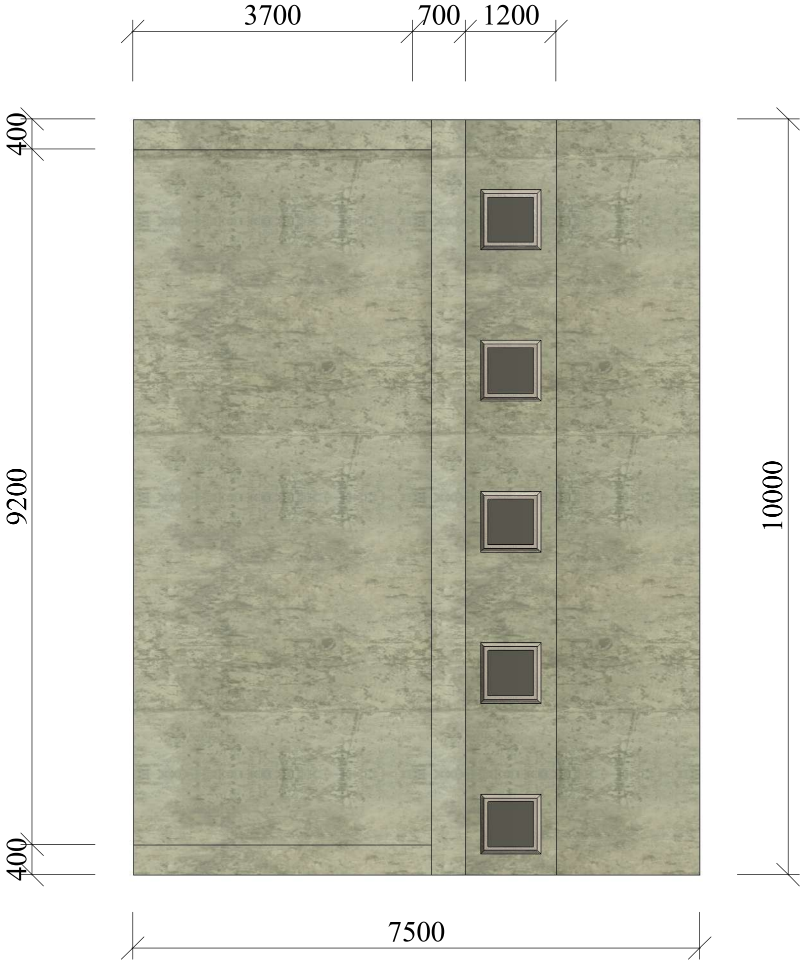
PROJECT	
PRESTRESSED CONCRETE BRIDGE	
DESIGN BY	AFDHIL
ID NUMBER	2110922064

PROJECT TITLE	SCALE
3D Modeling of Bridge Substructure	
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : STR - 06	6 / 8
DATE :	



Top View of Substructure
1 : 100

Side View of Substructure
1 : 100

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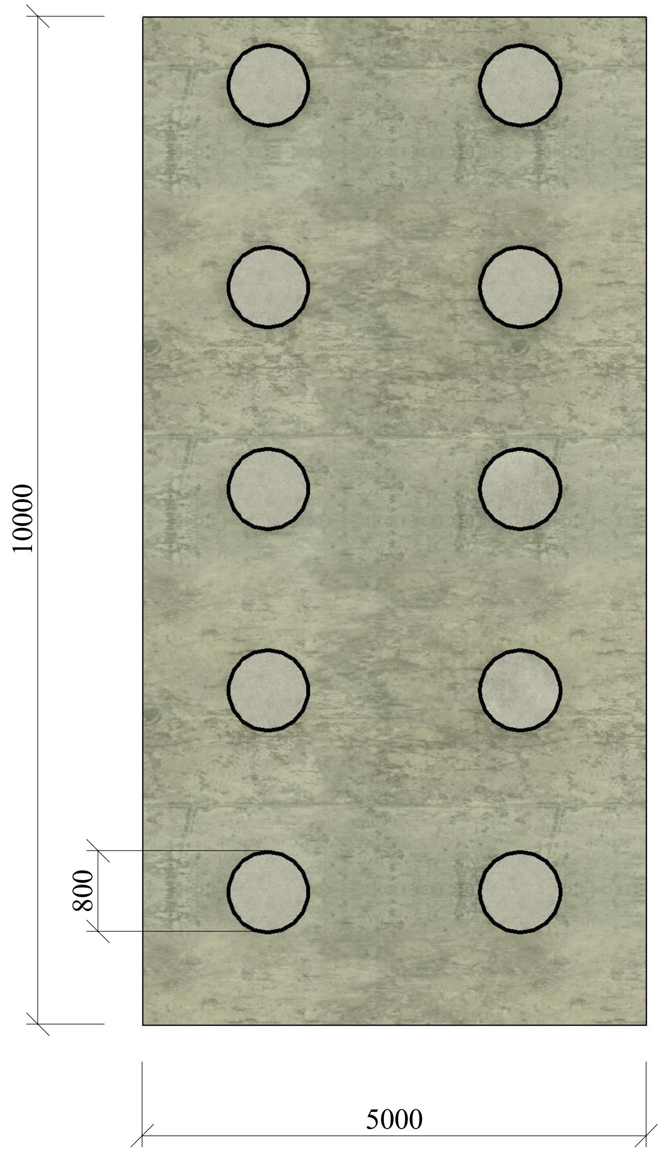
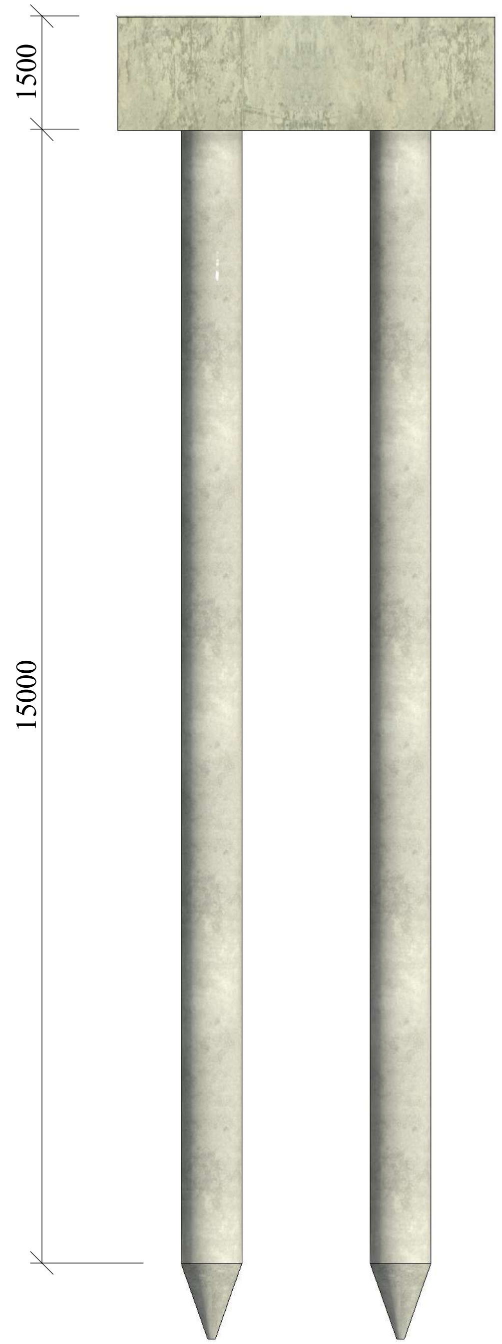
PROJECT	
PRESTRESSED CONCRETE BRIDGE	
DESIGN BY	AFDHIL
ID NUMBER	2110922064

PROJECT TITLE	SCALE
Dimension of Substructure	1 : 100
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : STR - 07	7 / 8
DATE :	



Top View of Pile Foundation

1 : 75



Detail of Pile Foundation

1 : 100

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2024

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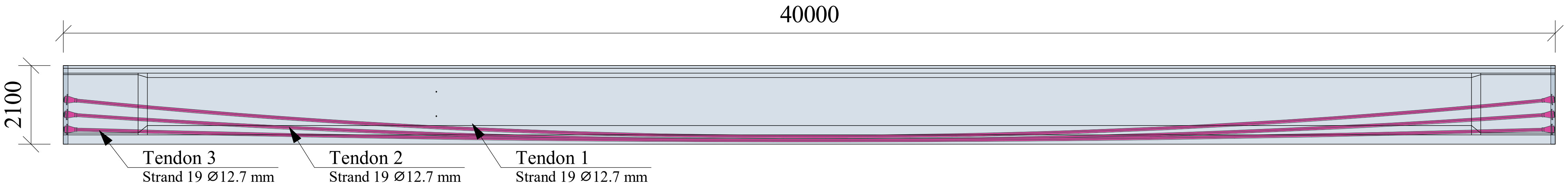
MASRILAYANTI, S.T, M.Sc, Ph.d **NIP . 197512192001122001**
PROJECT
PRESTRESSED CONCRETE BRIDGE

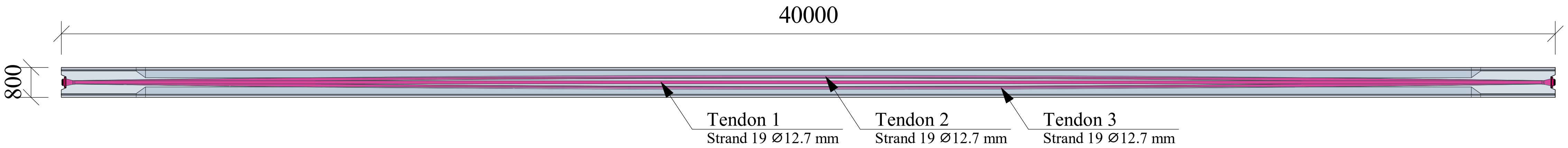
DESIGN BY	AFDHIL
ID NUMBER	2110922064

PROJECT TITLE	SCALE
Pile Foundation	As indicated
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : STR - 08	8 / 8
DATE :	



Tendon Side View

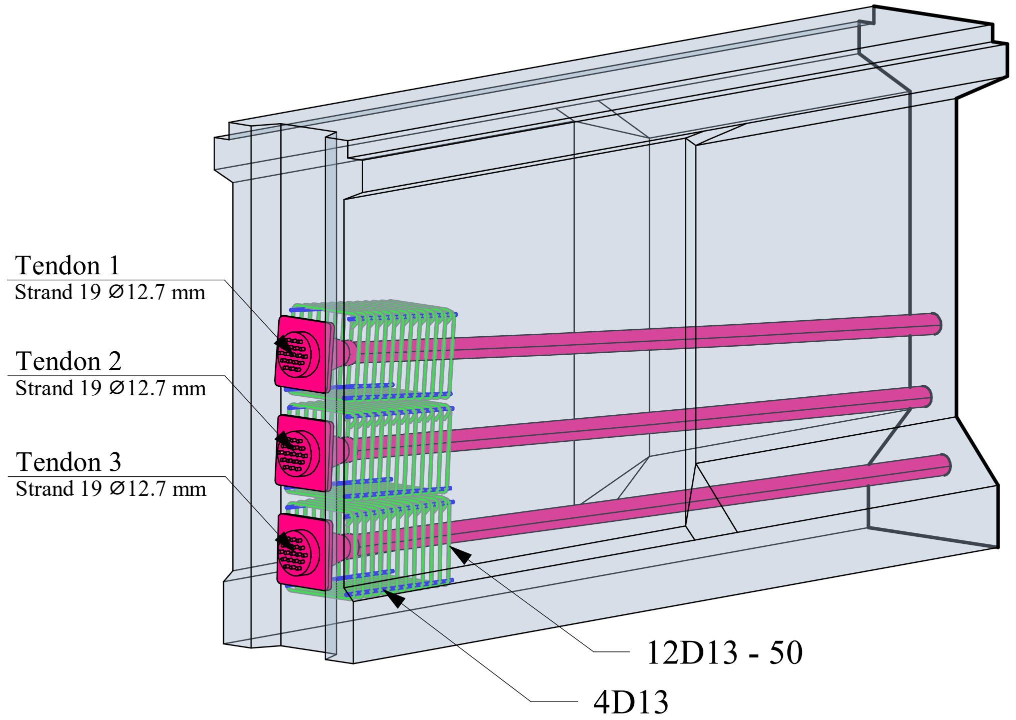
1 : 140



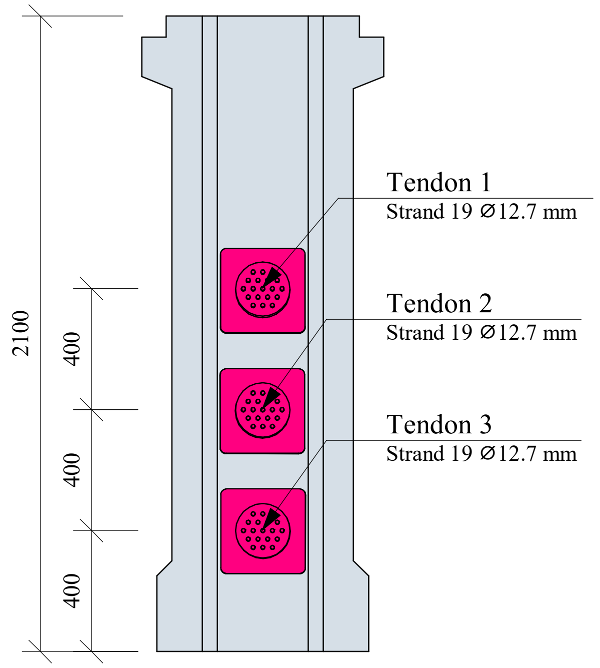
Tendon Top View

1 : 140

NO. CABLE	NO. PC STRAND DIA. 12.7mm	CABLE COORD	PROFIL (mm)		DISTANCE FROM BEAM EDGE (mm)																				
			EDGE	MIDDLE	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000	20000
1	19	X	1200	100	1200	1125	1051	977	904	833	764	696	632	571	513	458	408	362	322	286	256	232	215	204	200
		Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	19	X	1200	1200	800	748	695	644	593	543	494	448	402	359	319	281	246	214	185	160	139	122	110	103	100
		Y	1200	1200	0	-11	-22	-33	-44	-55	-65	-76	-85	-94	-103	-111	-119	-126	-132	-137	-142	-145	-148	-149	-150
2	19	X	1200	1200	0	378	355	333	311	290	269	249	230	211	194	177	162	149	136	126	117	110	104	101	100
		Y	1200	1200	0	11	22	33	44	65	76	76	85	94	103	111	119	126	132	137	142	145	148	149	150
TOTAL	57																								

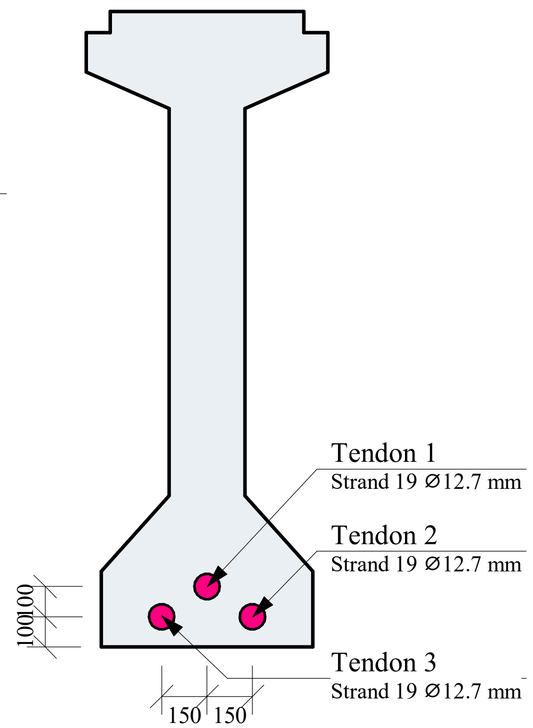


Tendon Perspective



End Section

1 : 25



Middle Section

1 : 25

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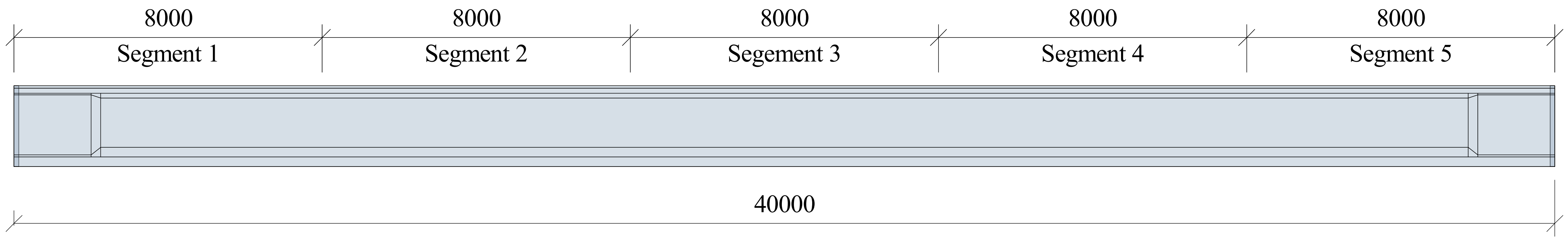
PROJECT

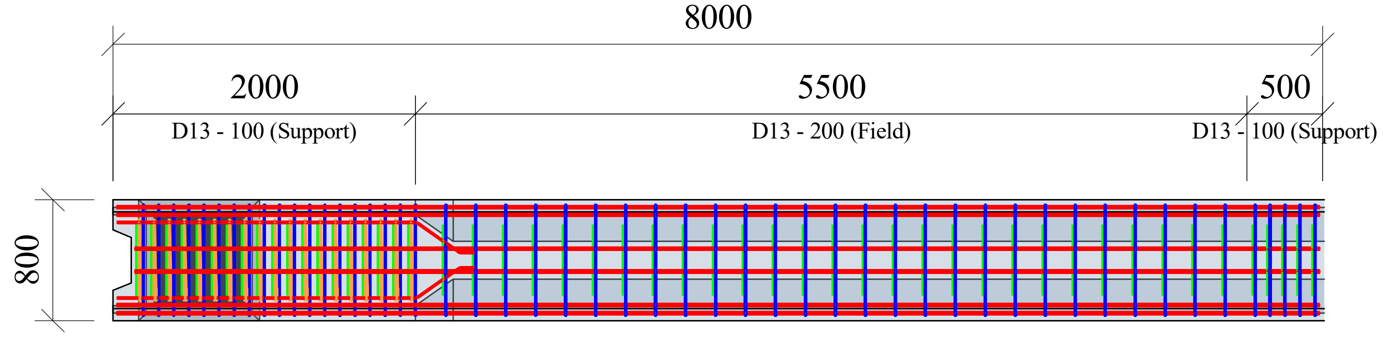
PRESTRESSED CONCRETE BRIDGE

DESIGN BY	AFDHIL
ID NUMBER	2110922064

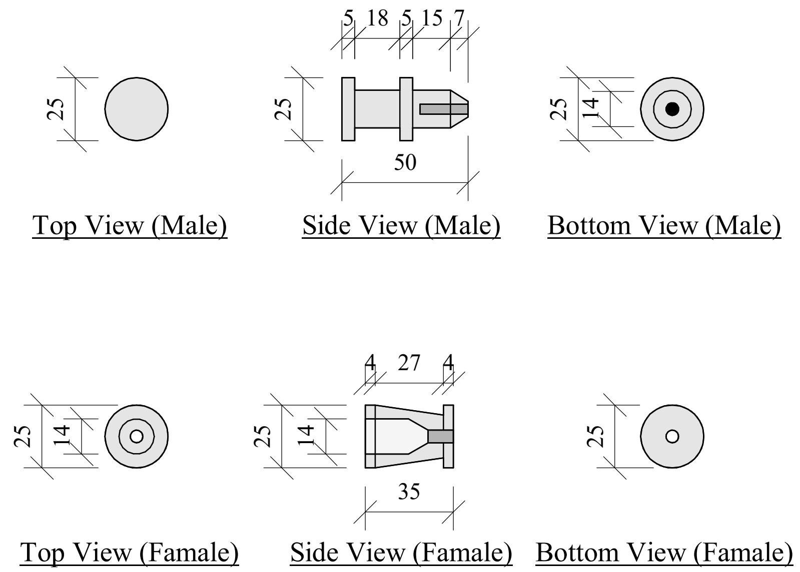
PROJECT TITLE	SCALE
Tendon Layout of PCI Girder	As indicated
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 01	1 / 13
DATE :	



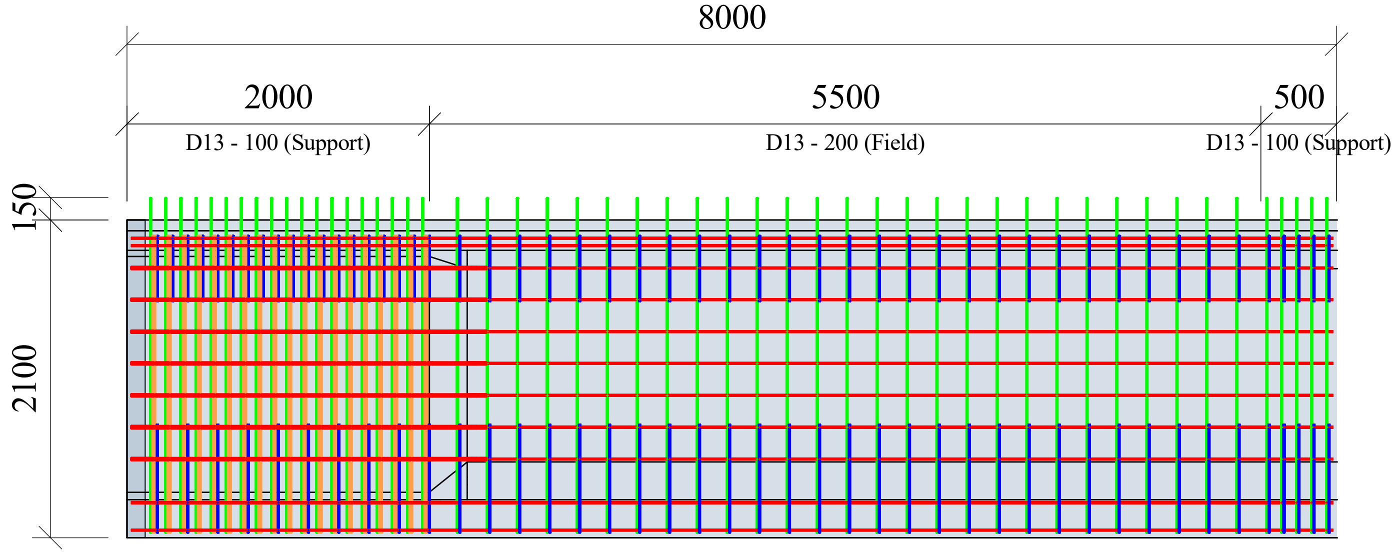
PCI-Girder L=40 m (Segmental)
1 : 140



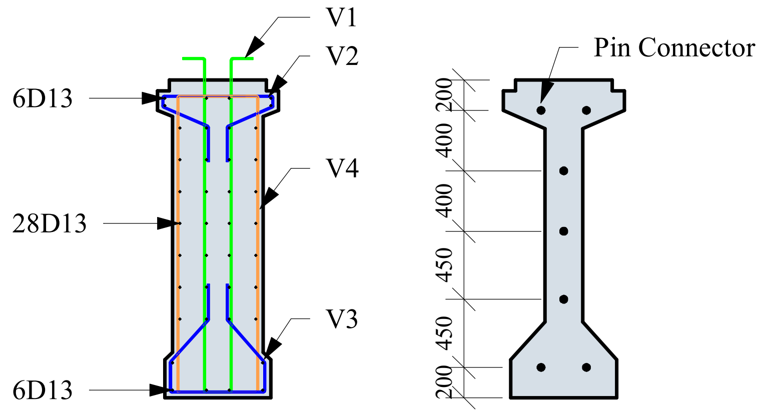
Top View of PCI-Girder Reinforcement
1 : 50



Pin Connector Detail
1 : 3



Side View of PCI-Girder Reinforcement
1 : 50



Cross Section of PCI-Girder
1 : 50

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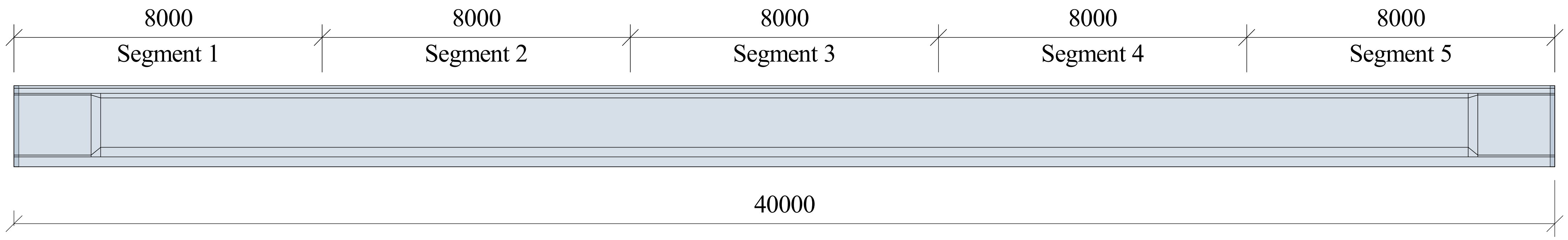
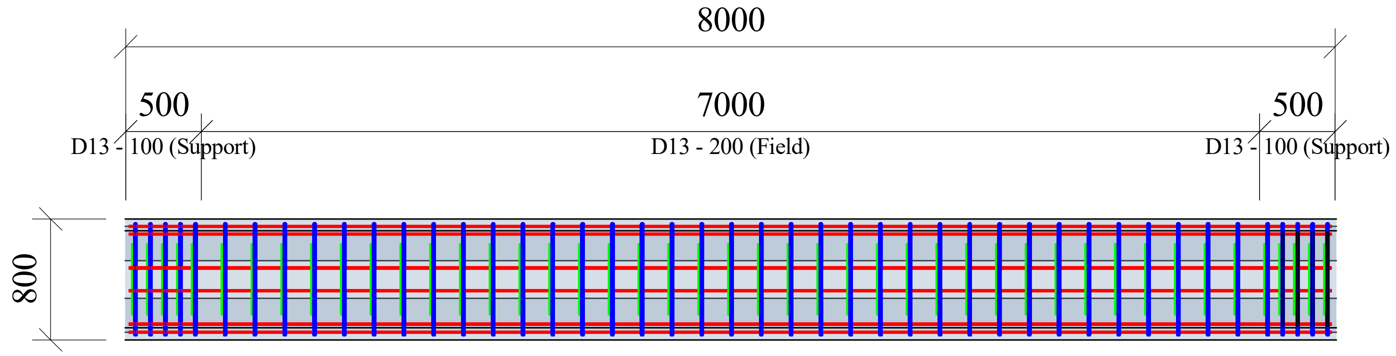
PROJECT	
PRESTRESSED CONCRETE BRIDGE	
DESIGN BY	AFDHIL
ID NUMBER	2110922064

PROJECT TITLE	SCALE
Reinforcement Details of PCI-Girder Segment 1 & 5	As indicated
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 02	2 / 13
DATE :	



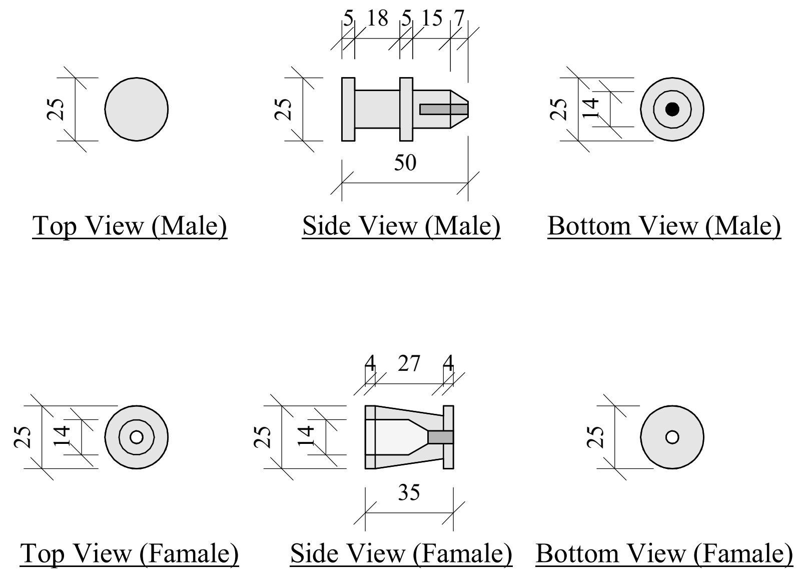
PCI-Girder L=40 m (Segmental) .

1 : 140



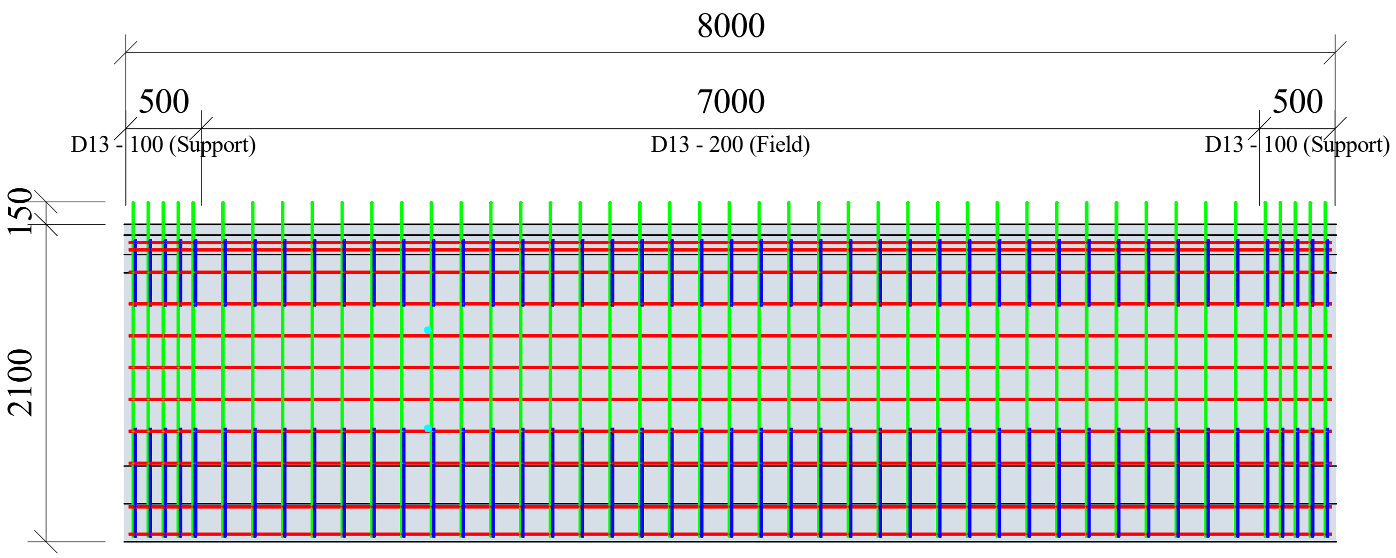
Top View of PCI-Girder Reinforcement .

1 : 50



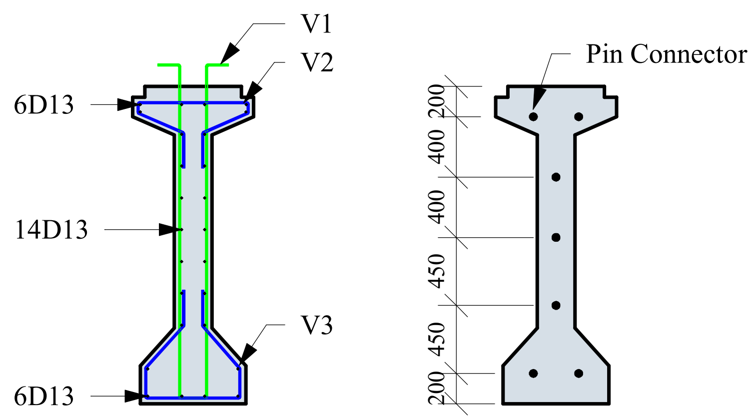
Pin Connector Detail

1 : 3



Side View of PCI-Girder Reinforcement .

1 : 50



Cross Section of PCI-Girder .

1 : 50

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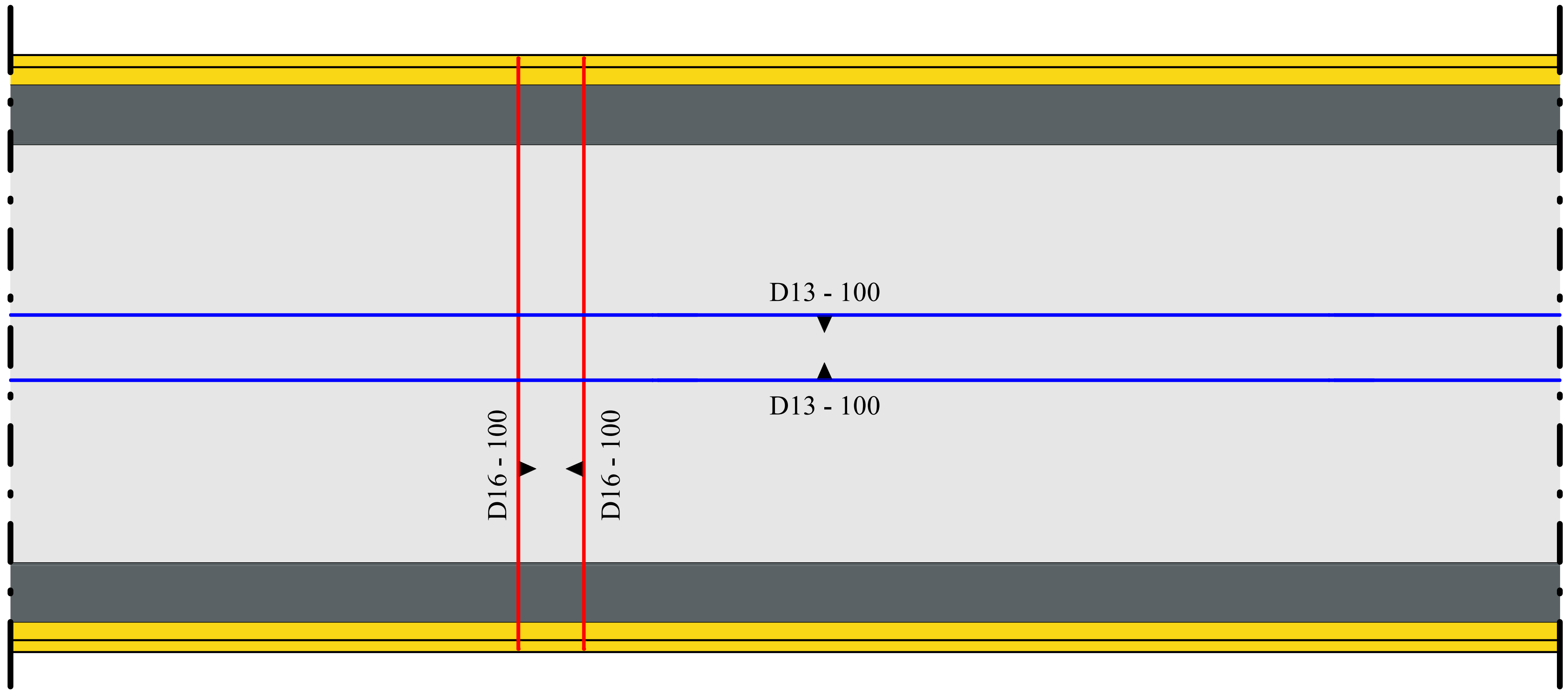
PROJECT

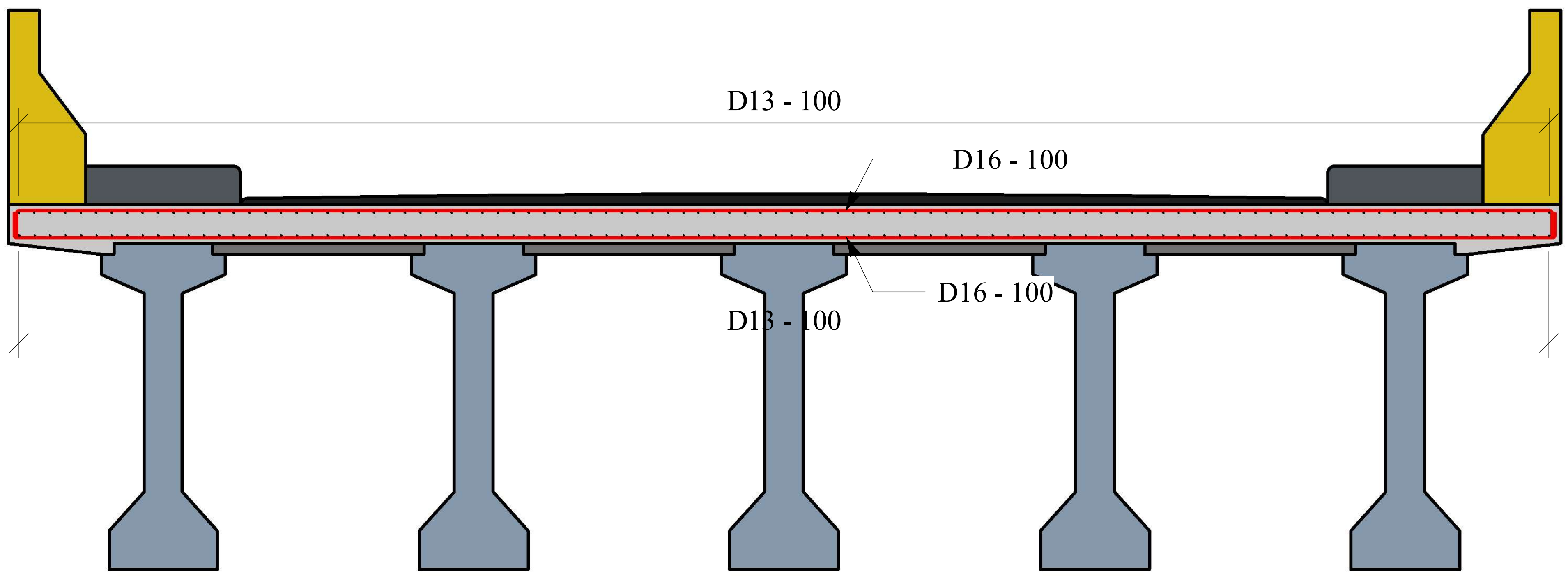
PRESTRESSED CONCRETE BRIDGE

DESIGN BY	AFDHIL
ID NUMBER	2110922064

PROJECT TITLE	SCALE
Reinforcement Details of PCI-Girder Segment 1 & 5 Copy 1	As indicated
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 03	3 / 13
DATE :	



Floor Slab Reinforcement
1 : 100



Section View of Floor Slab Reinforcement
1 : 40

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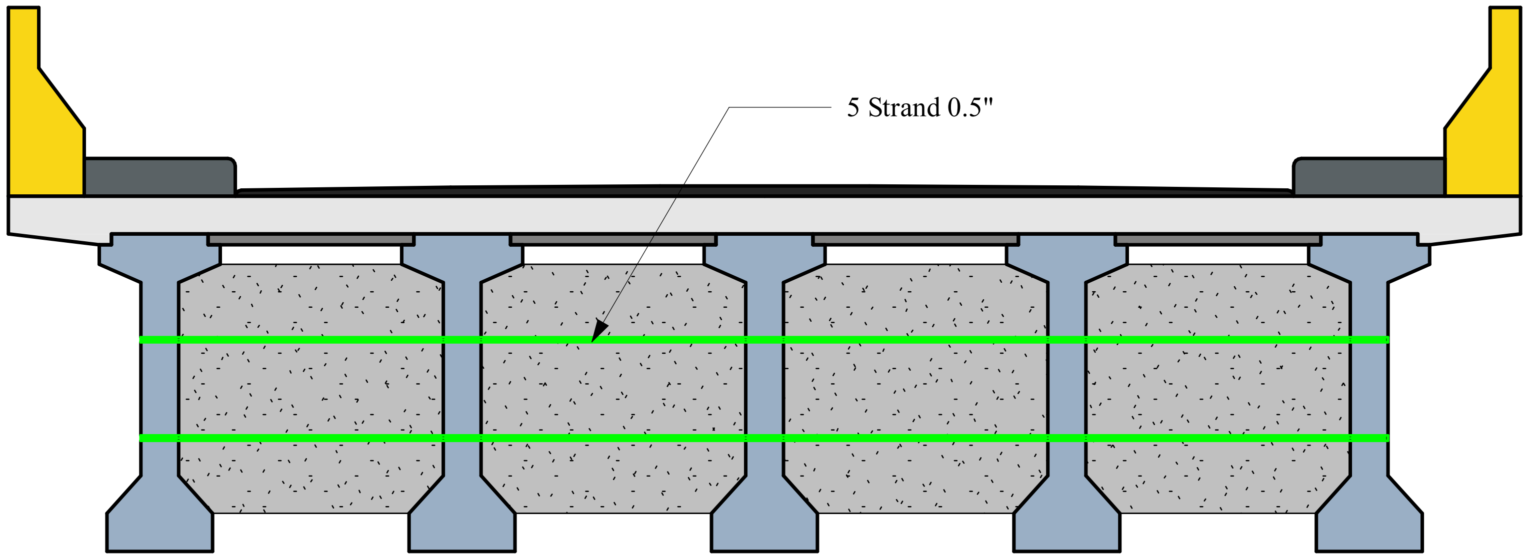
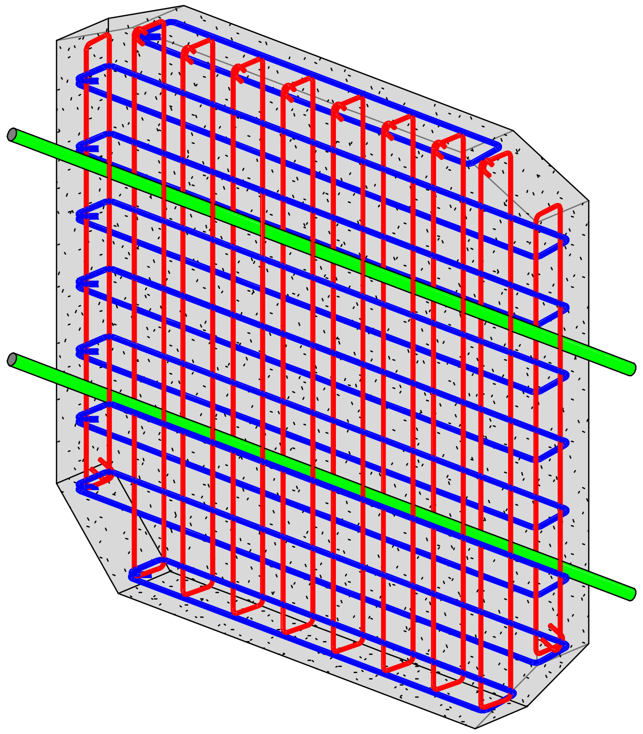
PROJECT	
PRESTRESSED CONCRETE BRIDGE	
DESIGN BY	AFDHIL
ID NUMBER	2110922064

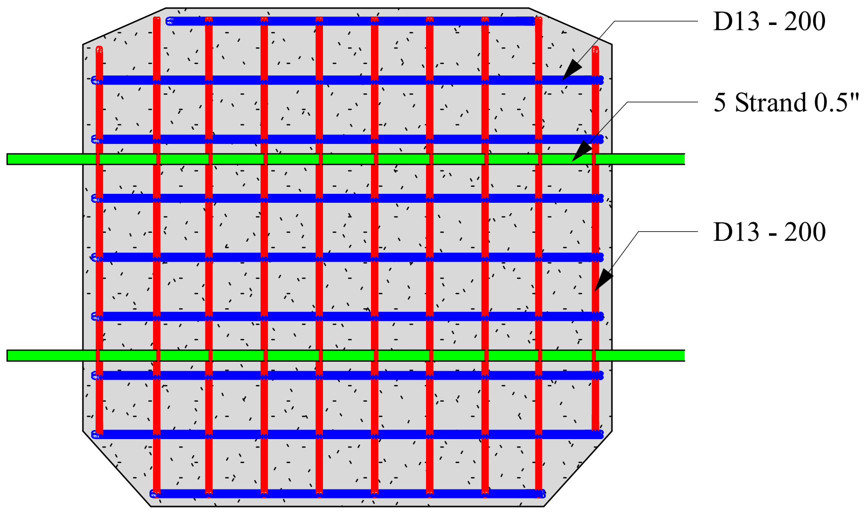
PROJECT TITLE	SCALE
Reinforcement Details of Floor Slab	As indicated
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 04	4 / 13
DATE :	



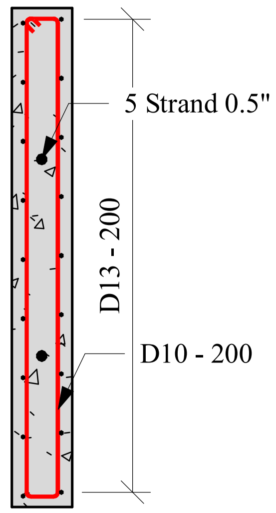
Layout of Diaphragm
1 : 50



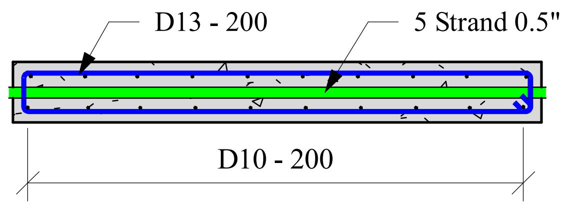
Reinforcement Perspective



Front View
1 : 25



Side View
1 : 25



Top View
1 : 25

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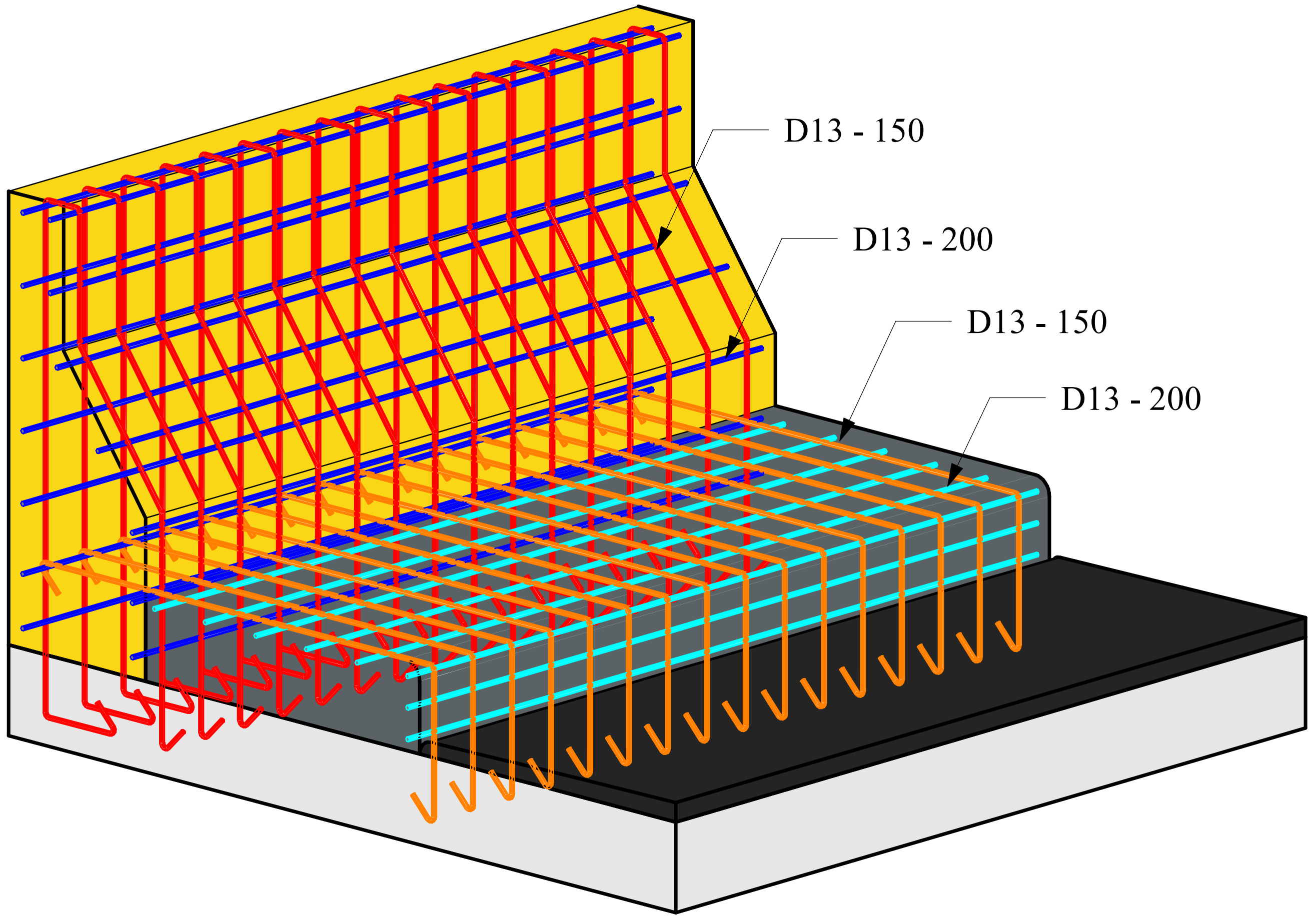
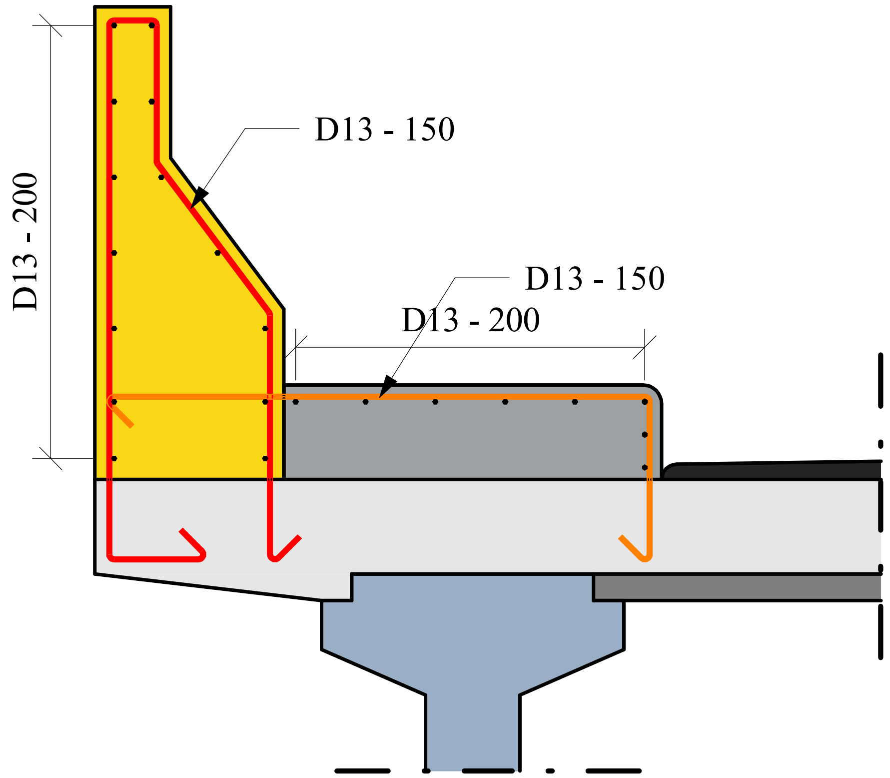
PROJECT TITLE	SCALE
Reinforcement of Diaphragm	As indicated
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 05	5 / 13
DATE :	



Reinforcement Perspecrive



Side View of Sidewalk and Barrier Reinforcement

1 : 20

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PROJECT

PRESTRESSED CONCRETE BRIDGE

DESIGN BY	AFDHIL
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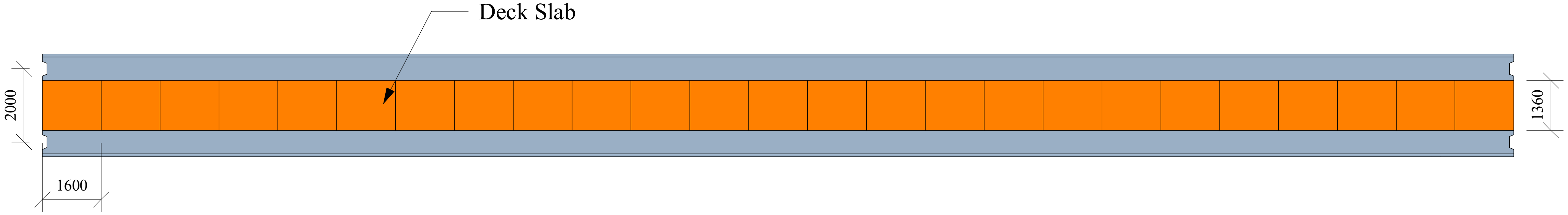
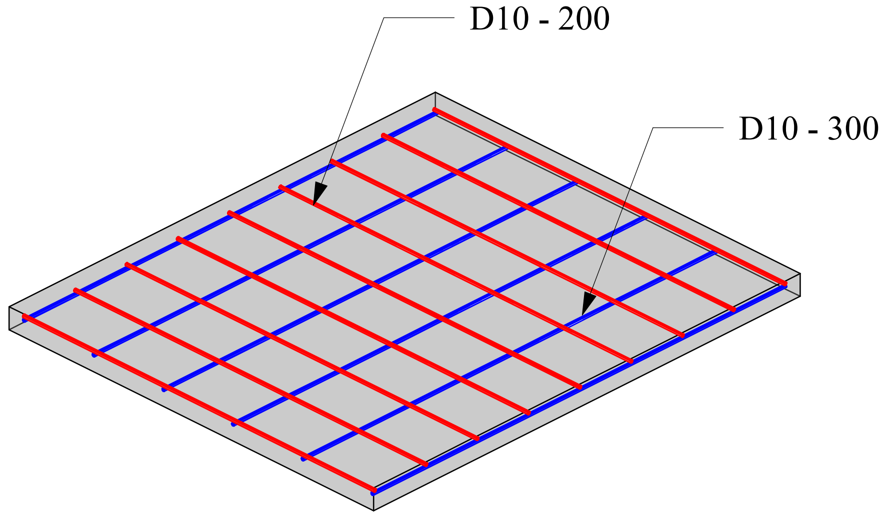
PROJECT TITLE	SCALE
Reinforcement Details of Barrier and Sidewalk	1 : 20
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 06	6 / 13
DATE :	

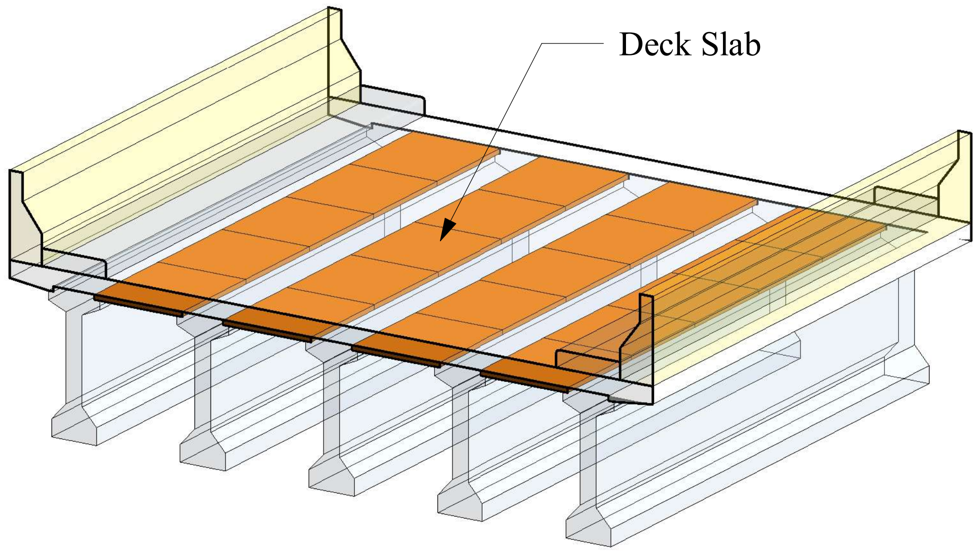


Deck Slab Top View

1 : 140



Reinforcement Perspective.



Deck Slab Perspective

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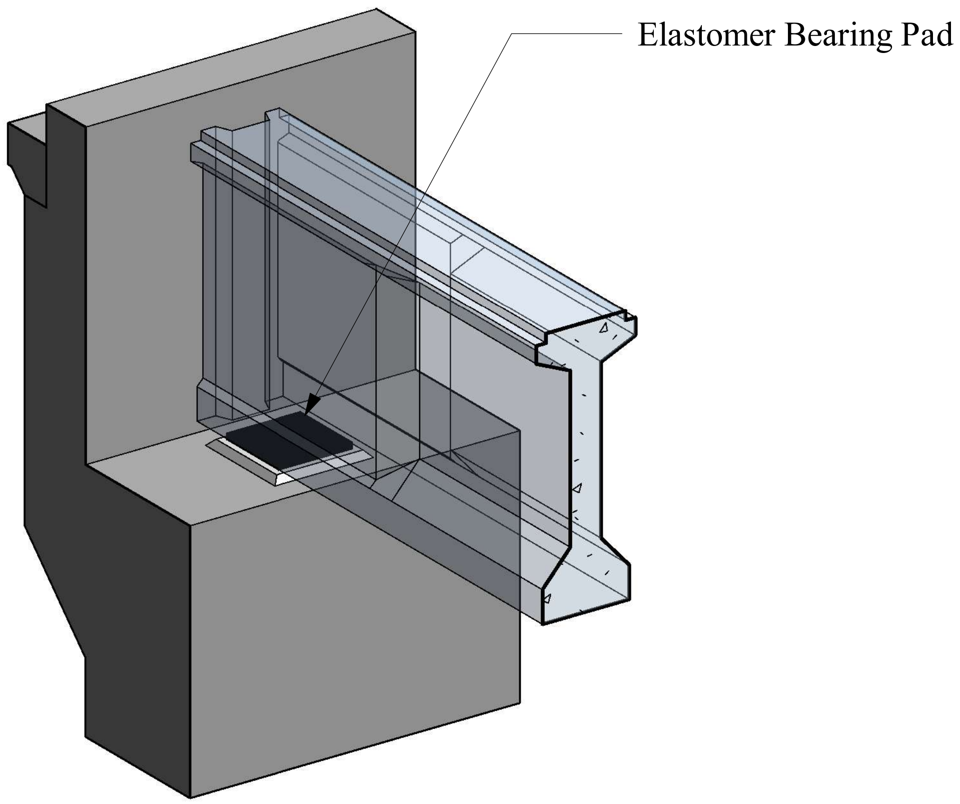
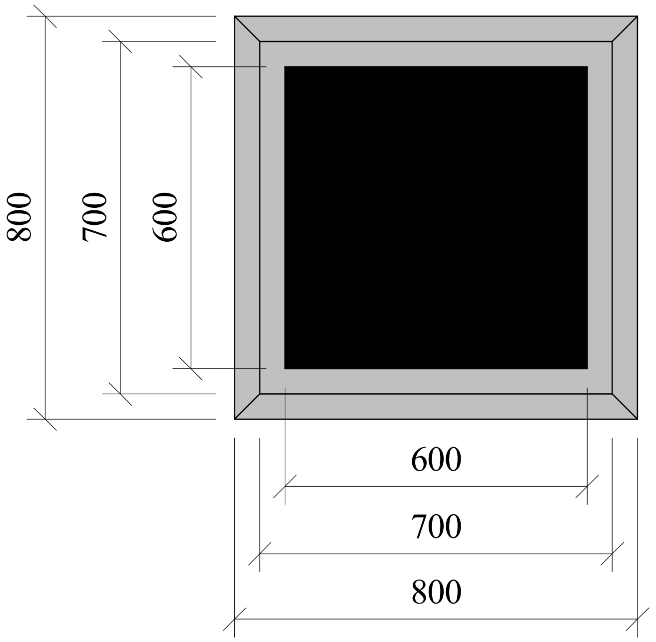
PROJECT

PRESTRESSED CONCRETE BRIDGE

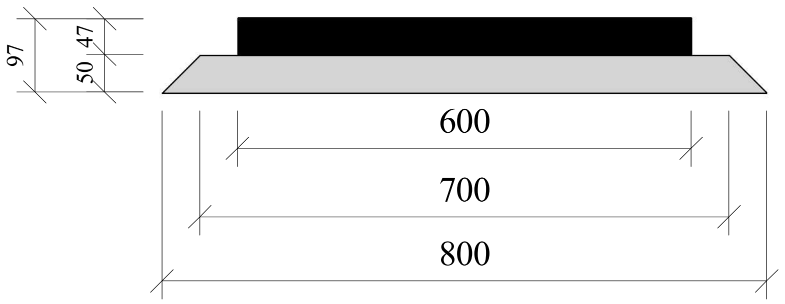
DESIGN BY	AFDHIL
ID NUMBER	2110922064
PROJECT TITLE	SCALE
Reinforcement Details of Deck Slab	1 : 140
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 07	7 / 13
DATE :	



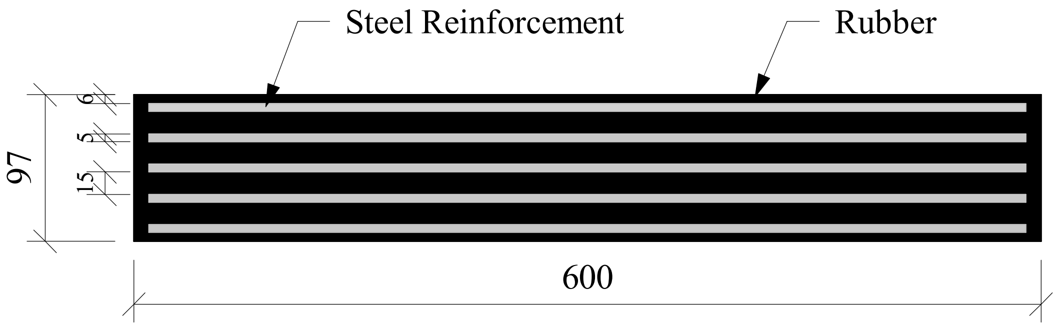
Perspective of Elastomer Bearing Pad



Top View of Elastomer Bearing Pad
1 : 15



Side View of Elastomer Bearing Pad
1 : 10



Section View of Elastomer Bearing Pad
1 : 5

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PROJECT	
PRESTRESSED CONCRETE BRIDGE	
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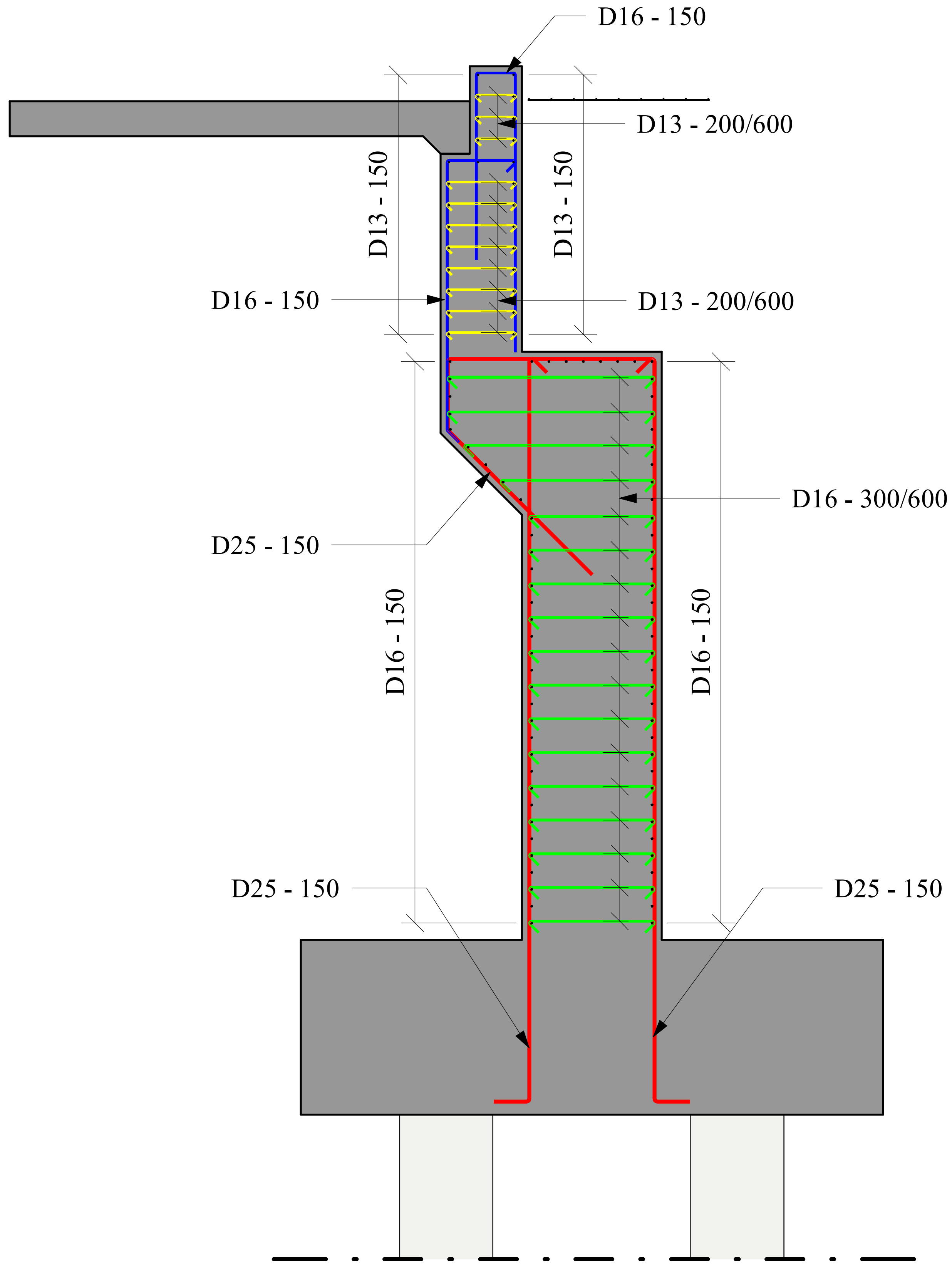
PROJECT TITLE	SCALE
Elastomer Bearing Pad Details	As indicated
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 08	8 / 13
DATE :	



Reinforcement of Breast Wall and Back Wall

1 : 50

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PROJECT	
PRESTRESSED CONCRETE BRIDGE	
DESIGN BY	AFDHIL
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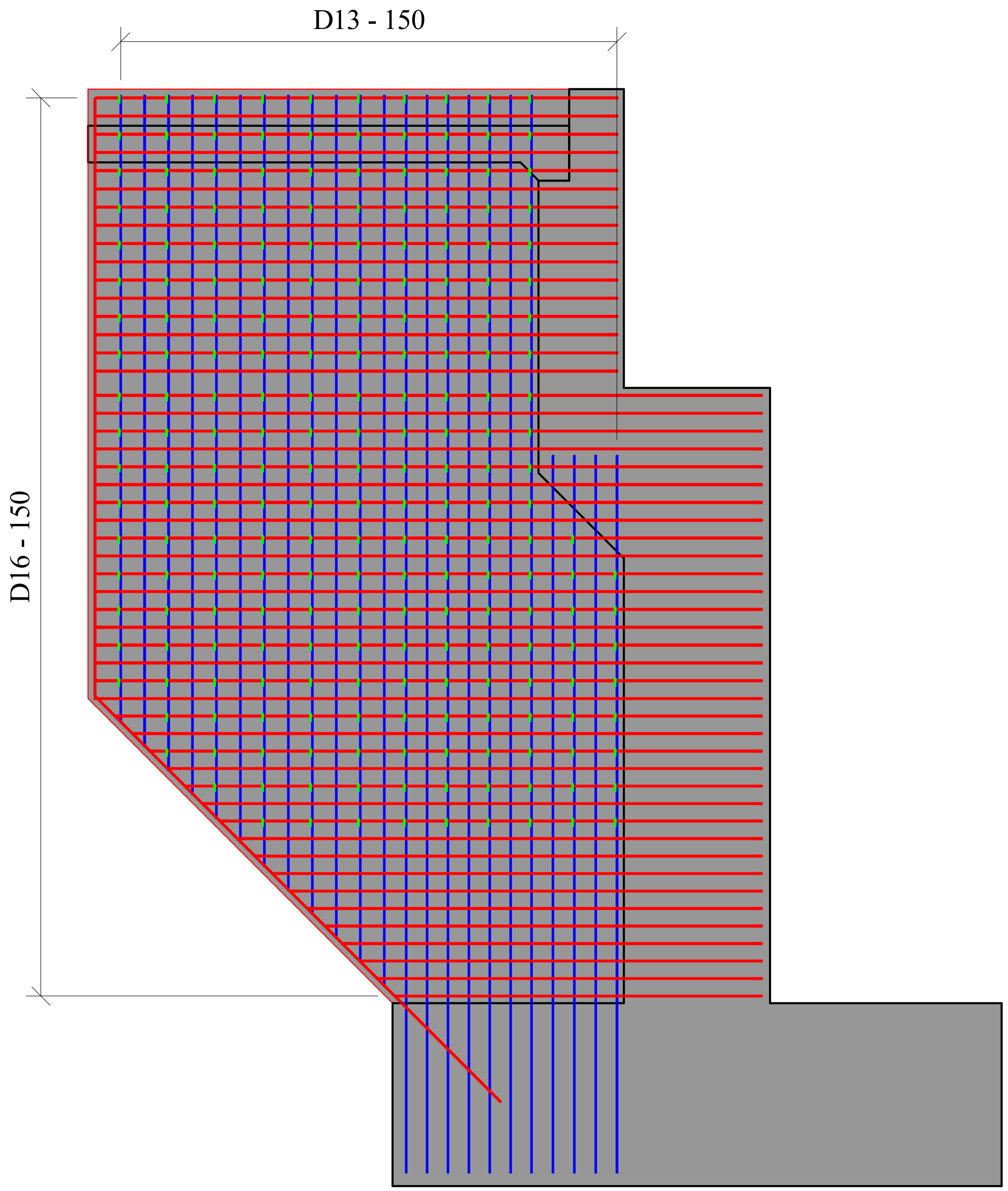
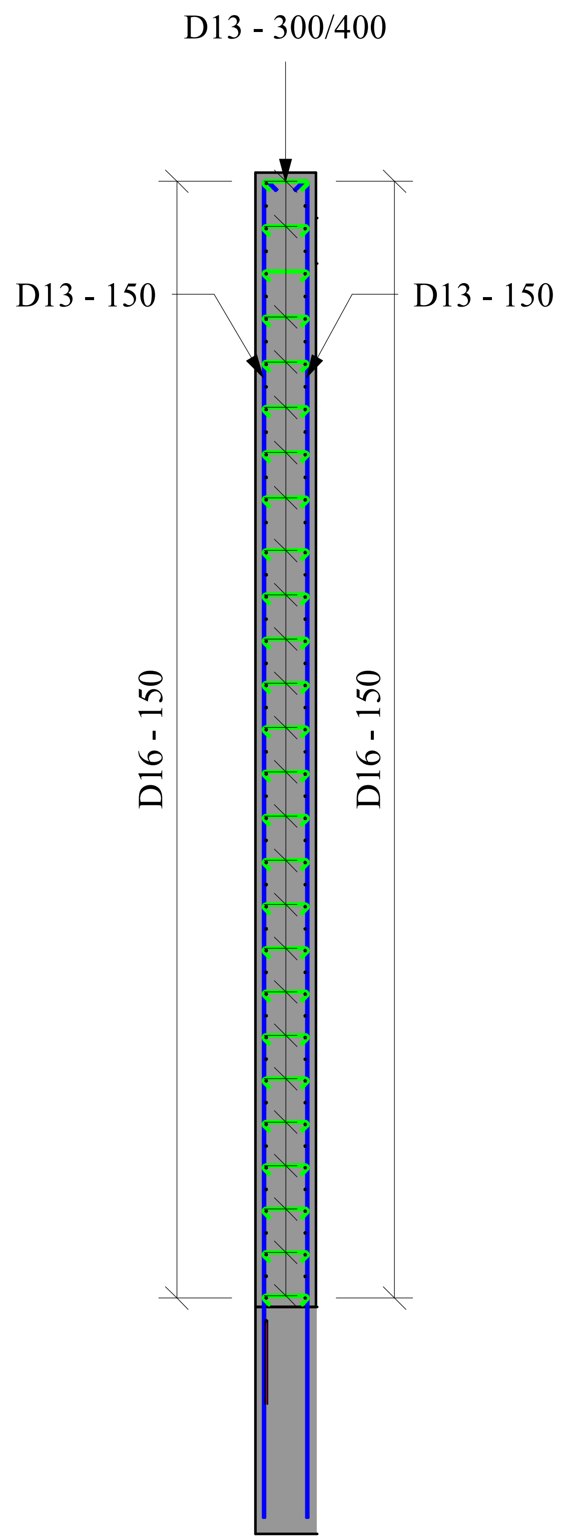
PROJECT TITLE	SCALE
Reinforcement Details of Breast Wall and Back Wall	1 : 50
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 09	9 / 13
DATE :	





Reinforcement of Wing Wall

1 : 50

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PRESTRESSED CONCRETE BRIDGE

DESIGN BY	AFDHIL
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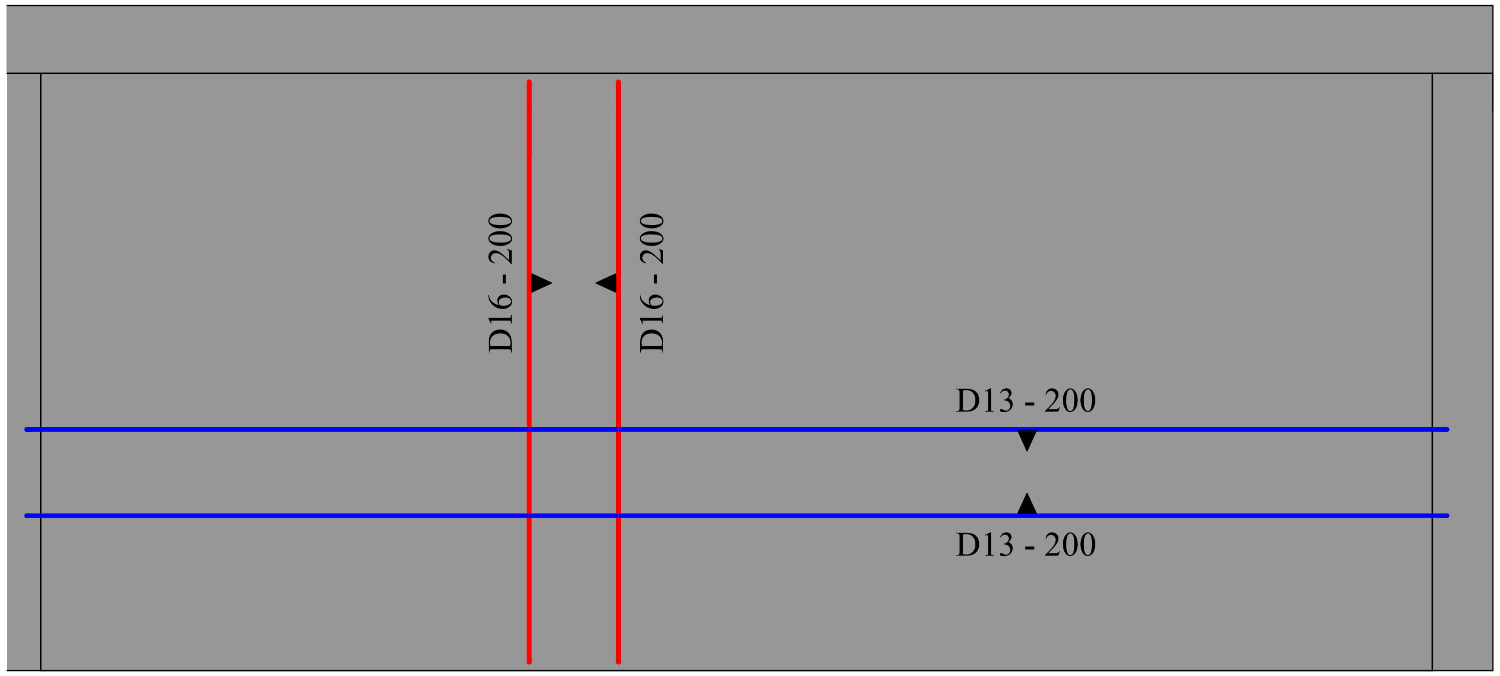
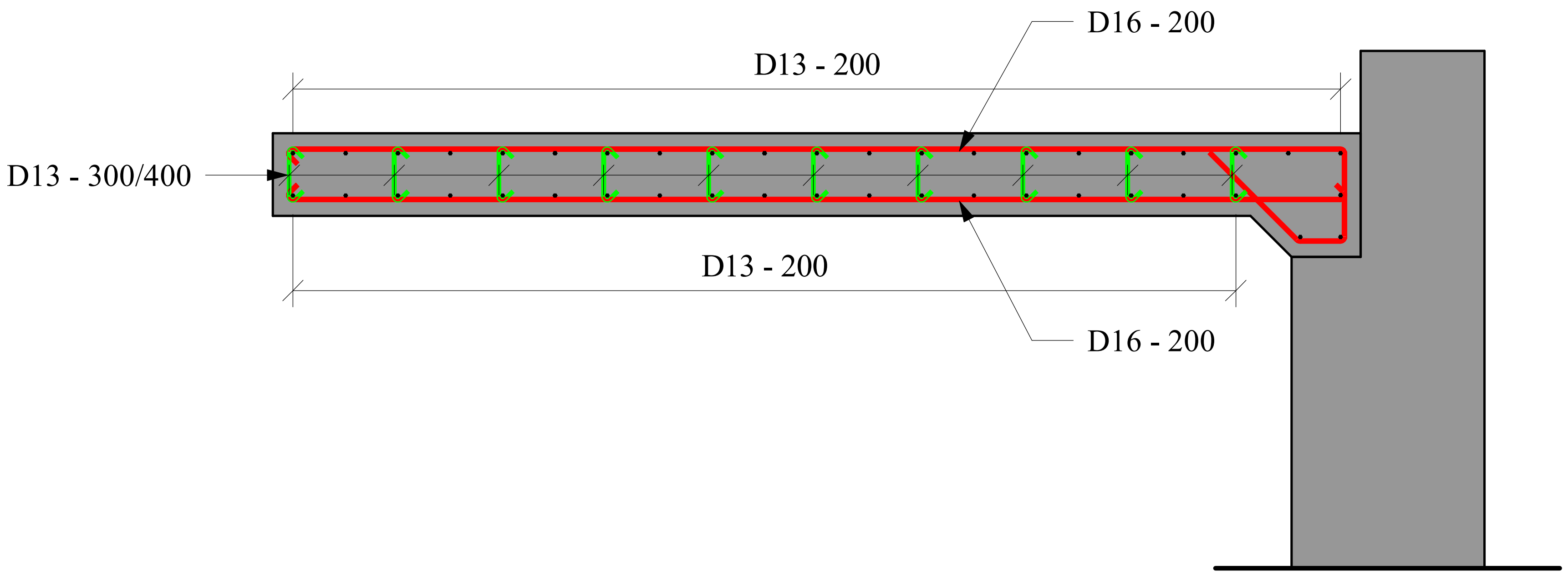
PROJECT TITLE	SCALE
Reinforcement Details of Wing Wall	1 : 50
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 10	10 / 13
DATE :	



Top View of Approach Slab
1 : 50



Side View of Approach Slab Reinforcement
1 : 25

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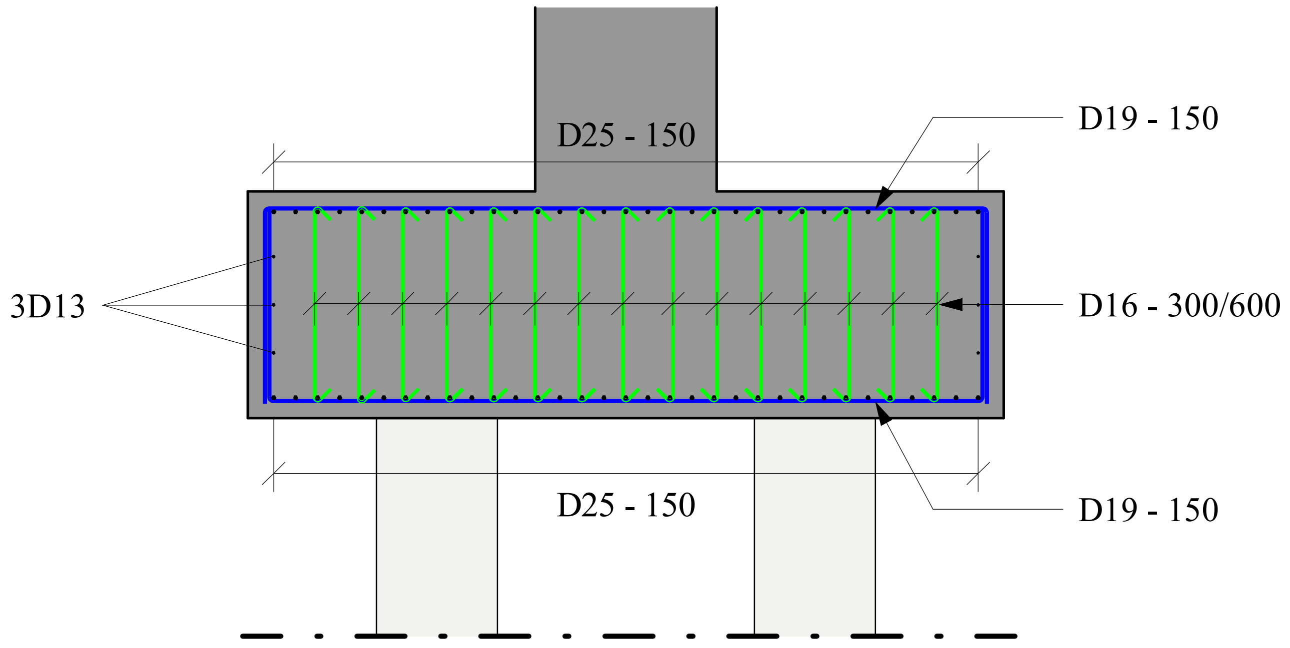
PRESTRESSED CONCRETE BRIDGE

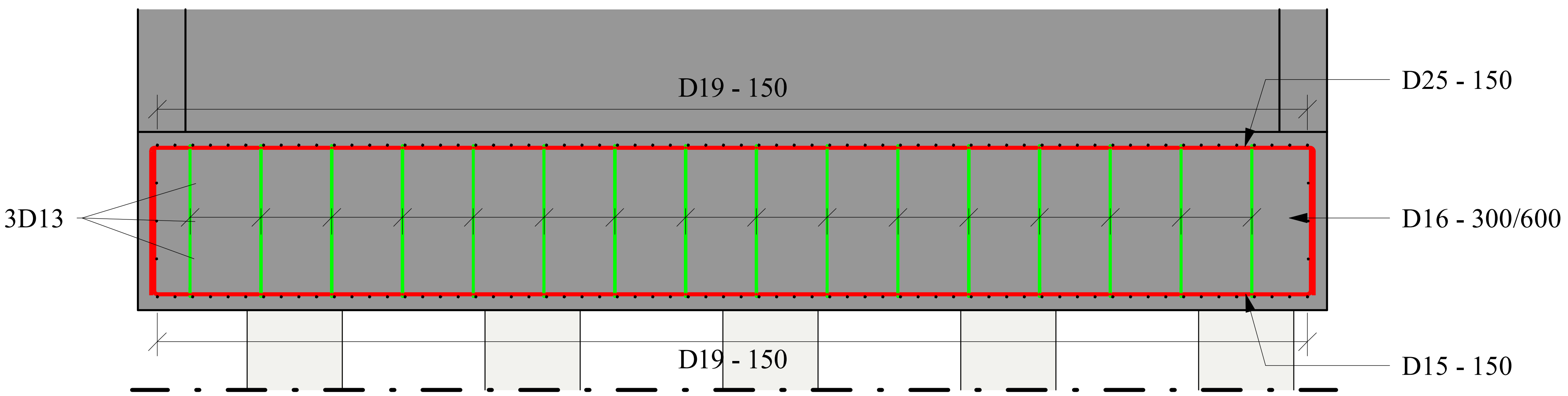
DESIGN BY	AFDHIL
ID NUMBER	2110922064

PROJECT TITLE	SCALE
Reinforcement Details of Approach Slab	As indicated
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 11	11 / 13
DATE :	



Longitudinal Direction Pile Cap Reinforcement

1 : 50



Transverse Direction Pile Cap Reinforcement

1 : 50

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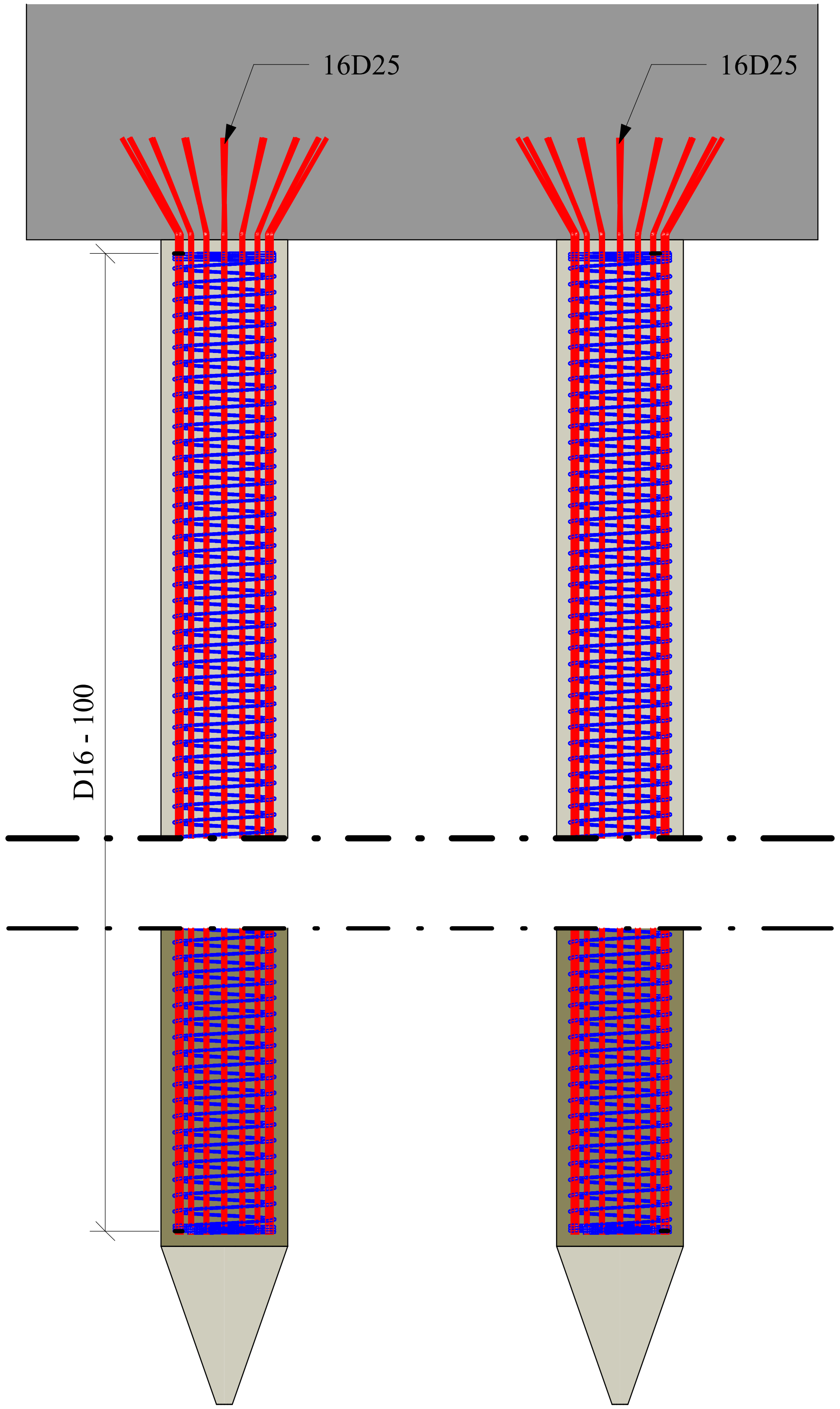
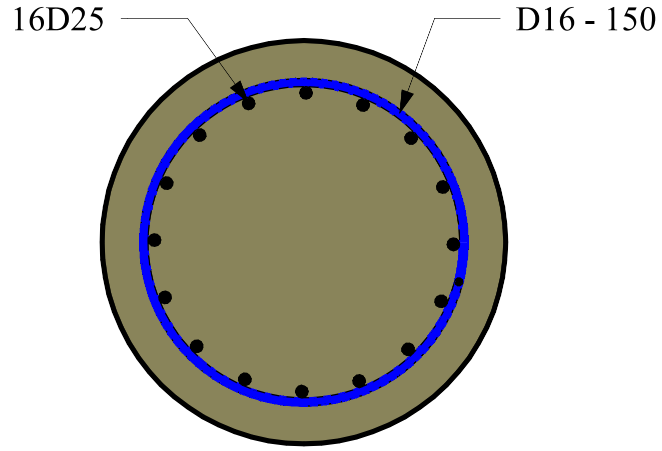
PROJECT TITLE	SCALE
Reinforcement Details of Pilecap	1 : 50
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 12	12 / 13
DATE :	



Side View of Pile Foundation Reinforcement

1 : 40



Top view

1 : 15

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PRESTRESSED CONCRETE BRIDGE

DESIGN BY	AFDHIL
ID NUMBER	2110922064

PROJECT TITLE	SCALE
Reinforcement Details of Pile Foundation	As indicated
PROJECT TYPE : STRUCTURE	PAGE / TOTAL PAGE
PROJECT TYPE : DTL - 13	13 / 13
DATE :	

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DEPARTEMEN TEKNIK SIPIL
Alamat: Gedung Departemen Teknik Sipil, Kampus Unand Limau Manis, Padang 25163
Telepon: 0751-72664; Fax: 0751-72566
Laman: http://sipil.ft.unand.ac.id Email: tekniksipil@eng.unand.ac.id

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NIM	:	2110922064
Judul TA/Tesis	:	DESIGN OF PRESTRESSED CONCRATE BRIDGE USING PCI-GIRDER BY IMPLEMENTING THE CONCEPT OF BUILDING INFORMATION MODELING (BIM)
Turnitin Submission ID	:	2565186166
Index Similarity	:	**17%**

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Padang, 16/01/2025
Diperiksa oleh:

Ayu Marta Mulya

Diketahui,
Dosen Pembimbing TA

Masrilayanti, S.T.,M.Sc.,Ph.D
NIP. 197512192001122001

AFDHIL-DESIGN OF PRESTRESSED CONCRETE BRIDGE USING PCI-GIRDER BY IMPLEMENTING THE CONCEPT OF BUILDING INFORMATION MODELING (BIM)

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