Report on

Structural Analysis and Design of Pedestrian Bridge in Urban Residential Area

Final Year Project

TEAM

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June 2023

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AUTHORIZATION

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EXECUTIVE SUMMARY

This executive summary provides a concise overview of the analysis conducted on two different bridge systems: a 4-girder deck system and a 2-girder deck system. The analysis was performed using the structural analysis software ETABS and verified with hand calculations. The objective was to determine the most viable option for the pedestrian bridge project. Based on the analysis results, it has been concluded that the 4-girder deck bridge system is more reliable than the 2-girder deck system. The 4-girder configuration demonstrated superior structural integrity and performance, meeting the design requirements and ensuring enhanced safety for pedestrians.

Additionally, the substructure system, including abutment piers and other components, was calculated to support the chosen 4-girder deck system. These calculations were performed in accordance with the BNBC 2022 (Bangladesh National Building Code), AASHTO and PWD (Public Works Department) standards to ensure compliance with local regulations and guidelines.

Furthermore, a comprehensive bill of quantity for the entire bridge project has been prepared. This bill of quantity details the required materials, quantities, and estimated costs for constructing the pedestrian bridge.

Moreover, a project schedule has been developed, aligning with the BNBC 2022 and PWD guidelines. The schedule outlines the timeline for different project phases, including design, construction, quality control, and project completion. This schedule facilitates effective project management, resource allocation, and coordination among various stakeholders.

In summary, the analysis conducted on the RCC Deck Girder Pedestrian Bridge project has determined that the 4-girder deck system is the preferred option due to its higher reliability. The project plans include the calculation of the substructure system, a bill of quantity for materials and costs, and a project schedule based on the BNBC 2022 and PWD regulations. These findings and deliverables provide a solid foundation for the successful implementation of the pedestrian bridge project.

CHAPTER-1
INTRODUCTION

1.1 PROJECT BACKGROUND

Banasree and Aftabnagar area is one of the residential areas in Dhaka city. The Banasree has sequented into particular sections and blocks, Aftabnagar has oriented in the same way. Right now there are several places from where people are overpassing the mid canal for going two sides of the canal. There are temporary bridges in several places throughout the canal, this is basically a temporary bamboo wooden bridge. Over time these bridges were recovered at particular times as well. Recently the bamboo bridge near the Banasree C Block was constructed in the year of 2018 and in the middle of 2019 it was repaired for the safety purpose. Then also this bridge is unsafe due to unauthorized mechanisms and unsafe loading conditions. These areas are considered the educational, institutional and residential areas, so locals of these areas are mostly students, teachers, bankers and more educated people. On the side of the Banasree there are lots of commercial shops for clothes, foods and more for the daily needs and other groceries as well. But Aftabnagar is more with residential buildings. RC the pedestrian bridge will ensure the safety of the Banasree Aftabnagar overpass area. It will also reduce the daily hassle and overpassing time problems of the people in That area. Overall the rcc pedestrian bridge will be able do this beneficials,

- Provide pedestrian and bicycle bridges to enhance multimodal access to regional transit centers.
- Support the city's larger growth strategy for transforming.
- Least environmental impact.
- Aesthetics.
- Minimal disruption to traffic during construction.
- Sustainability and minimum maintenance.
- Cost savings.
- Public safety.

1.2 PROJECT REQUIREMENTS

a. The bridge location, formation level and height must be proposed by considering all the related issues accordingly such as navigation issue, hydrological issue and to maximize the pedestrian usages etc.

b. Safety and serviceability of the bridge must be ensured as per applicable codes and standards.

c. The architecture and shape of the bridge should be unique, attractive, and appealing.

d. The structural design should be optimized to make the bridge cost-effective.

1.3 OBJECTIVES

The objectives of the project are as follows:

1. Selection of a suitable bridge type and site for the project.
2.Preliminary structural design considering factors such as structural integrity, aesthetics, and functional requirements.
3. Finalizing the structural design of the bridge based on safety and performance criteria.
4. Drafting of the structural design.
5. Preparing Bill of Quantity (BOQ) based on materials, quantities, and estimated costs.
6. Developing a project schedule that outlines the sequential steps and timelines for the bridge construction process.

1.4 LITERATURE REVIEW

The history of pedestrian bridges dates back to ancient times, when people first needed to cross rivers, valleys, and other obstacles to reach their destinations. Some of the earliest examples of pedestrian bridges include the pontoon bridges of ancient Rome and the wooden bridges used by the Inca civilization in South America.

Over time, the design and construction of pedestrian bridges evolved to meet the changing needs of societies. During the Middle Ages, for example, covered bridges were built to protect pedestrians from the elements, while the industrial revolution saw the introduction of iron and steel as building materials, allowing for the construction of larger and more elaborate pedestrian bridges. In the 20th century, advances in materials and construction techniques allowed for the development of new types of pedestrian bridges, including suspension bridges and cable-stayed bridges. At the same time, the growth of urban areas and the increasing need for pedestrian access across busy roads and highways led to a greater focus on pedestrian bridge design and safety. **[McCormac, Jack C. and Brown, Russell H, New Jersey.2014]**

There are several types of pedestrian bridges, each with its own unique design features, construction materials, and intended use. Some of the most common types of pedestrian bridges include,

A. <u>Suspension Bridges</u>: Suspension bridges are characterized by their long spans and graceful appearance, and are typically made of steel cables suspended from towers. They are commonly used to cross valleys, rivers, and other large obstacles.

B. <u>Cable-Stayed Bridges</u>: Cable-stayed bridges are similar to suspension bridges, but instead of suspending the deck from cables, the deck is supported by cables that are attached directly to towers. This type of bridge is often used for shorter spans, such as those encountered in urban areas.

C. <u>Arch Bridges</u>: Arch bridges are made of a series of arches that support the deck of the bridge, and are commonly constructed from stone, concrete, or steel. They are well suited for spans of moderate length and are often used in urban areas.

D. <u>Truss Bridges</u>: Truss bridges are made of a series of interconnected triangular elements that support the deck of the bridge. They are commonly constructed from steel and are often used for longer spans.

E. Beam Bridges: Beam bridges are the simplest type of pedestrian bridge, consisting of a single beam that spans the gap and supports the deck of the bridge. They are often made of concrete or steel, and are used for short spans.

F. Footbridges: Footbridges are typically small and simple pedestrian bridges that are used to cross smaller obstacles, such as streams or railway tracks. They may be made of a variety of materials, including wood, steel, or concrete.

Each type of pedestrian bridge has its own unique design features, construction materials, and intended use, and the choice of bridge type will depend on the specific needs of the location and the users. When selecting a pedestrian bridge, it is important to consider factors such as the span length, the obstacle being crossed, the type of traffic that will be using the bridge, and the available budget.

Pedestrian bridges are structures that are specifically designed for the use of pedestrians, and as such, there are several design considerations that are unique to this type of bridge. These considerations are crucial to ensure that the bridge is accessible, safe, durable, and aesthetically pleasing.

Accessibility is an important consideration for pedestrian bridges, as it is crucial to ensure that the bridge is easily accessible to all users, including those with disabilities. This means that the bridge should have a wide, unobstructed walkway with a non-slip surface and a railing for safety. In addition, ramps or elevators should be provided for users who are unable to use stairs, and handrails should be placed at a convenient height for users who need additional support.

Safety is another key consideration for pedestrian bridges. The structure should be designed to withstand heavy loads, and it should also have adequate lighting to ensure that users can see where they are going. The bridge should also have safety features such as guardrails or safety nets to prevent users from falling off the bridge.

Durability is another important factor in the design of pedestrian bridges. The bridge should be constructed using materials that are able to withstand the elements, including rain, wind, and snow, as well as the weight of users. The bridge should also be designed to withstand regular maintenance, such as repainting and cleaning, without compromising its structural integrity.

Aesthetics is also an important consideration for pedestrian bridges. The bridge should be designed to complement its surroundings, and it should also be visually appealing to users. This may include the use of decorative elements, such as lighting, sculptures, or architectural features. In addition, the bridge should be designed to provide users with a pleasant experience, including unobstructed views and comfortable seating.

Reinforced Cement Concrete (RCC) is a popular choice for pedestrian bridges because of several benefits it offers:

- Durability: RCC is a strong and durable material that is able to withstand heavy loads, as well as the elements, including rain, wind, and snow. This makes it ideal for pedestrian bridges, which are subjected to regular use and exposure to the elements.

- Low Maintenance: RCC is a low-maintenance material that does not require frequent repairs or replacement, making it an economical choice for pedestrian bridges.

- Cost-effective: RCC is a cost-effective material that offers a good balance between durability and affordability. This makes it a popular choice for pedestrian bridges, which may need to be built on a budget.

- Customization: RCC can be molded into various shapes and sizes, making it an ideal choice for pedestrian bridges that require unique designs and customizations.

- Fire resistance: RCC has a high fire resistance, making it a safer option for pedestrian bridges.

In conclusion, RCC is a versatile and cost-effective material that offers durability, low maintenance, fire resistance and the ability to be molded into unique designs, making it a popular choice for pedestrian bridges.

Steel is another popular material choice for pedestrian bridges due to several benefits it offers:

- Strength and stability: Steel is a strong and stable material that can withstand heavy loads and provide the necessary support for pedestrian bridges.

- Flexibility: Steel can be easily molded into various shapes and sizes, making it a flexible material for pedestrian bridge design.

- Lightweight: Steel is a relatively lightweight material compared to concrete, making it easier and more cost-effective to transport and install, especially for longer bridges.

- Aesthetics: Steel has a sleek and modern appearance, making it a popular choice for pedestrian bridges that require a visually appealing design.

- Fire resistance: Steel has a high fire resistance, making it a safer option for pedestrian bridges.

- Ease of maintenance: Steel is a low-maintenance material that does not require frequent repairs or replacement, making it an economical choice for pedestrian bridges.

Steel is a strong, flexible, lightweight, and visually appealing material that offers fire resistance and low maintenance, making it a popular choice for pedestrian bridge design

Reinforced Cement Concrete (RCC) and Steel are both popular materials for pedestrian bridges, and the choice between the two depends on several factors, including:

Cost: RCC is generally a more cost-effective option compared to steel, especially for smaller pedestrian bridges. This is because RCC is a relatively cheap material and does not require additional costs for painting or corrosion protection, unlike steel.

Durability: RCC has a high durability and can withstand heavy loads and exposure to the elements, making it an ideal choice for pedestrian bridges that will be subjected to regular use and exposure to the elements.

Maintenance: RCC is a low-maintenance material that does not require frequent repairs or replacement, making it an economical choice for pedestrian bridges. Steel, on the other hand, may require more frequent maintenance, such as painting and corrosion protection, to keep it in good condition.

Aesthetics: RCC has a more traditional appearance, making it a popular choice for pedestrian bridges that require a classic or timeless design. Steel has a sleek and modern appearance, making it a popular choice for pedestrian bridges that require a visually appealing design.

After careful evaluation and analysis of both RCC (Reinforced Concrete) and steel pedestrian bridge options, we have concluded that the RCC Pedestrian Bridge is the optimal choice for our project. There are several key reasons behind this decision.

Firstly, RCC bridges exhibit remarkable durability and longevity, making them suitable for enduring heavy pedestrian traffic and various environmental conditions. This ensures the bridge's longevity and minimizes the need for frequent maintenance and repairs.

Secondly, from a cost perspective, RCC bridges offer significant advantages. They generally have lower construction and maintenance costs compared to steel bridges, making them a cost-effective solution over the bridge's lifespan. Furthermore, the aesthetic appeal of the RCC Pedestrian Bridge is a crucial consideration. It can be seamlessly designed to blend with the surrounding urban residential area and canal, enhancing the overall visual harmony and architectural appeal. Local availability of materials also played a significant role in our decision-making process. RCC materials are often more readily accessible, reducing transportation costs and potential delays associated with sourcing steel materials. Construction efficiency was another vital factor. RCC bridges can be constructed efficiently using standardized construction methods, resulting in timely completion and minimal disruptions to the area.

In conclusion, the selection of the RCC Pedestrian Bridge ensures a reliable, cost-effective, visually appealing, and durable solution that aligns with the project's objectives. It will serve the urban residential area and canal efficiently, enhancing connectivity, safety, and overall urban aesthetics for years to come.

1.5 REVIEW OF SUPPLIED DOCUMENTS

The client has supplied some documents to review them. The supplied documents are soil report, AASHTO code, BNBC (Bangladesh National Building Code), and PWD (Public Works Department) regulations. The findings and observations of the documents below:

Soil Report:

The soil report provides valuable information regarding the site's geotechnical conditions. The report includes details on soil types, groundwater levels, soil strength parameters, and other relevant properties. The information provided in the soil report is crucial for foundation design and determining soil bearing capacity. No significant discrepancies or omissions were identified in the soil report. Below is an explanation of our soil report:

Number of Borehole:

The number of boreholes can vary depending on the purpose and scale of the project. A total of 4 boreholes have been drilled in our project location to know the maximum bearing capacity. In the soil report, bearing capacity of 3 number borehole was maximum, so we have done substructure calculation with bearing capacity of 3 number borehole.

Length of Borehole:

The length of a borehole refers to the depth or vertical distance it extends into the ground. Borehole lengths can vary significantly depending on the purpose and requirements of the project. The geological composition and characteristics of the subsurface can influence the length of a borehole. Some formations may require deeper drilling to access the desired resources or to obtain accurate geological data. In our project, 4 boreholes had a maximum bearing capacity of 27 meters. So we worked with 27meter borehole.

Width of Borehole:

The width or diameter of a borehole refers to the size of the hole's opening or the cross-sectional measurement of the drilled cavity. Borehole diameters can vary depending on the purpose of the drilling and the specific requirements of the project. The size of the borehole in our soil test was 750mm.

Soil Type:

Our project location 27meters depth soil is Medium Sandy Soil. Medium Sandy Soil have small particles and feel sticky when wet. They have poor drainage but excellent water and nutrient retention.

Maximum Bearing Capacity:

The maximum bearing capacity of a borehole refers to the maximum load that can be supported by the soil surrounding the borehole without causing excessive settlement or failure. It is an important consideration in geotechnical engineering and foundation design. The bearing capacity of a borehole is influenced by various factors, including the properties of the soil, the dimensions of the borehole, and the applied load. Determining the maximum bearing capacity requires geotechnical investigations and testing. Our maximum soil bearing capacity is 2436 KN. Our maximum soil-bearing capacity is 2436 KN. Which we got for 27m in borehole number 3.

1.6 SITE VISIT

Banasree-Aftabnagar roads are one of the franchise busiest locations for the north city people. The office goers and new dhaka city people are living in these places by having extra advantages of malls, parks, wide roads, well named schools and colleges. People often go for a walk to the Aftabnagar long area over the bamboo pedestrian bridge. Since the residential area Aftabnagar has started to build the apartments and local roads the demand for pedestrians has increased day by day. The people are in need of a permanent pedestrian bridge over the canal.

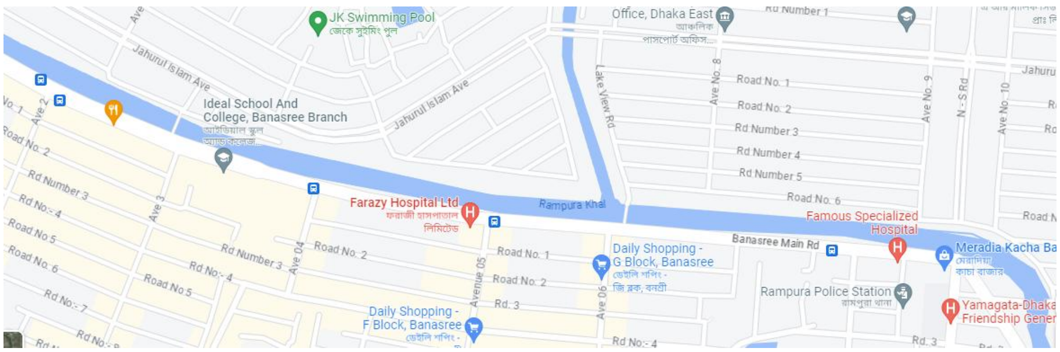


Figure 1.3 : Rampura Canal Google Map Picture

The project site is in Between of Banasree-Aftabnagar Main Bypass road, North Dhaka City-1219. The bamboo wooden pedestrian bridge is made to that place to overpass the local peoples and daily passerby and for thousands of people's everyday use. As per the history of that place there the canal is the part of the Balu river. The wooden bamboo bridge there is the only capable bridge to deliver people from one side to another side, while repairs were done in 2018 to secure the structure, but it remains unsafe for pedestrian use. Thus this bridge is not only connecting the two societal areas but also it is one of the important concerning issues for the societal peoples. There are nearly three to four bamboo wooden bridges over the canal in several places. The bamboo pedestrian bridge is constructed of local bamboo with a basic frame structure from a number of parallel timber logs and ropes and spans approximately 100+ feet over the canal. It is supported by the bamboo foundation that has been deeply dug under the canal. The bridge carries daily passengers' live loads and sometimes heavy loads are carried over the bamboo bridge, which is nearly unsafe for the people.

During our site visits in September 2022, we surveyed the local community and received overwhelming feedback highlighting the pressing need for a pedestrian bridge in the area. The residents expressed their desire for improved safety and convenience, emphasizing the significance of the proposed bridge for their daily commute and accessibility.

As the inspection visit we have gone through 4 possible overpass areas in between Banasree and Aftabnagar, our supervision team has inspected and taken the notes of every place conditions and what the nearby peoples think of the area and how they respond to the bridge. Here are the two possible areas discussed,

Near Block C Banasree: This place has a high crowd supported area, in particular when there is overload on the bamboo pedestrian bridge we have focused on. There are 3-4 academic institutions that students overpass to their destination by using the pedestrian, Banasree C block is one of the main entrances of the Banasree residential area. There are also three bus stops we have noted. Identically this place will be more benefited if we install the pedestrian bridge here.

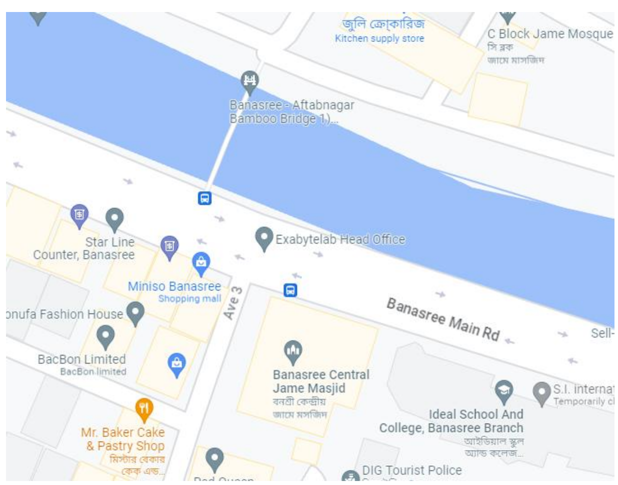


Figure 1.4: Google map of Rampura canal near block C

Figure1.5: Location near Banasree C block

<u>Meradia Bazar</u>: This place is different from the above two areas, as there is a bazaar in that area. People of that area are wishing to have a bridge near this area. As they are saying, the economical condition will be improved if the bridge is installed here.

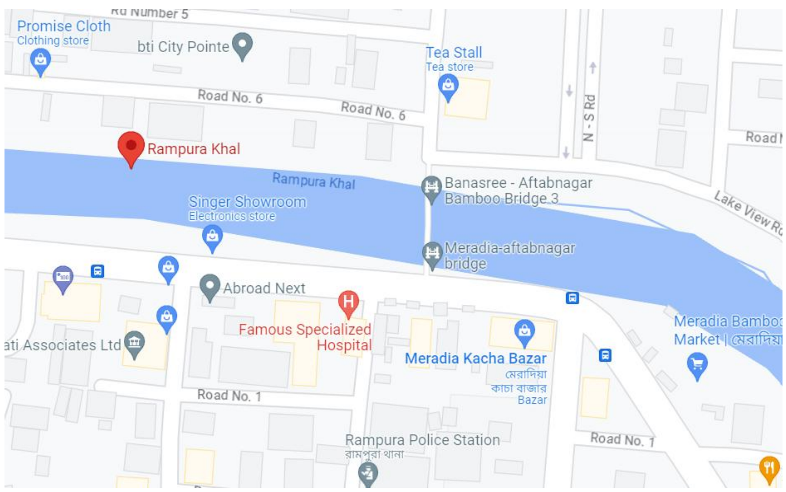


Figure 1.6 : Map location of Meradia bazar canal area

Figure 1.7 : Location of Meradia Bazar

1.7 PROJECT IMPACTS

1.7.1 Environmental Impacts

1.7.1.1 NOISE

The noise level most of the time in this city is more than twice the tolerable standard, which is causing long term damage to physical and mental health of the city dwellers. The pedestrian bridge is proposed to be over the rampura canal between Banasree and Aftabnagar. In this area noise pollution happens. One of the main causes of noise pollution is the traffic and loud horns in the Banasree main road. In Dhaka 80% of the noise pollution originates from vehicles.

Block C: In Banasree block C near the mosques there is a traffic signal where many vehicles especially buses gather and pollute the area with loud horns. Near in block d there are Ideal School and two mosque so the people who pray, study there face problems and it's hard to concentrate on their study and prayers.

Meradia area: In Meradia area there is also a bus stand and bazaar which causes total chaos so there is also noise problem happen. In meradia, the construction work is also another reason for noise problem. People who live around the area have to face the problem . This can affect people in the long run. Noise pollution can create health issues like high blood pressure, hormonal imbalances. In the bazaar there are many people working and there the seller brings fish vegetables and other essential things carried by vehicles so it creates chaos.

Proposed action

The construction work is another important reason for noise pollution. There construction work going on especially in Aftabnagar area. Construction equipment used in construction areas like mixer machine, excavation, tamping and others causes the noise in that area.

During the construction of pedestrian bridges there can be hazardous noise levels. In block C ,since there are school college mosques ,the prayer time and study time can be disturb. Depending upon the type and stage of construction different types of equipment used. The noise may vary. Noisy activities on construction include the use of dump trucks, cement mixer, tamping machines and others as well as noise generated from hand tools such as hammer drills. In meradia, people live there,also have a big bazaar so the construction noise can be a problem.

Mitigation

In **block C** near there are mosques and schools in that area construction workers need to be careful.Otherwise students can get district due to the construction noise. Also during prayer time it can be difficult to pray when the construction works. That's why we need to take safety precautions and training so there is no unnecessary noise like during prayer time the work can be stopped so people can pray.

In the **Meradia** area since there is a bazaar during construction time chaos can happen. To avoid that, site engineers have to manage that properly so people in that area work or live don't face problem. We can warn the residents about construction times through a public service announcement. Also during important times construction work can be stopped for some moment so people don't face problems.

1.7.1.2 WATER

The current situation of Banasree canal in the capital has virtually turned into a dumping ground for garbage disposed of by nearby households and trader of **Meradia** Bazar. Due to the mindless dumping of waste materials into the canal from its rampura bridge to Meradia Bazar point, the water body becomes a breeding ground for mosquitoes while its heavily polluted water spreads bad odor. Reason Behind Pollution:

- Overpopulation
- Mismanagement of land
- The Authorities do not care about waste dumping.
- People of this area hardly use the dustbins or even use those are not enough for the amount of people in that area.

At block c the water is not covered in plants. And at meradia water can't be seen because of heavy plants in the water.

Proposed action

In block c area, during the construction period some chemicals can be dumped in the canal water. Which can ham the water. Also the construction materials like cement, gravel can get waste onto the water if workers work carelessly. This can harm or make obstacles in the water way.

In meradia, the material, construction elements can create problems for the water ways. Also various materials can be dumped in the canal if the workers are not careful. Figure:1.8

Rampura canal banasree block c

<u>Mitigation</u>

The construction engineer and workers need to ensure that water can't be more polluted.

In block c area, they need to be extra careful while working in that area.During construction workers need to be careful that there won't be any waste or chemicals thrown on the water.

In the Meradia area , there are site engineers and workers who need to be careful about working on the water. The waterways boat can move properly on the canal during the construction and after the construction period that needs to be ensured.

Figure: 1.9 Near meradia bazar

1.7.1.3 SOIL

Soil pollution refers to the contamination of soil with anomalous concentrations of toxic substances. This is a serious environmental concern since it harbors many health hazards. Causes of the soil pollution can be both natural and manmade.

Figure:1.10 Near meradia bazaar

One of the most common causes of soil pollution is improper disposal of waste. Because the Banasree area is densely populated there waste management is one of the worst.

In **meradia,** since there is a bazaar the waste is huge.People throw the waste like plastic, polythene on the road side, into the canal. While doing the survey in that area we see a lot of waste is openly dumped into the area , in the canal side, which as time goes on can be very harmful for the soil.

In **block c** the waste is actually not that much compared to the meradia area.But still there are also people who throw waste carelessly in that area.

Proposed action

In block c area,during the construction period some chemicals can be dumped in the canal side Which can harm the soil in that area.Also the construction materials or workers can make obstacles near the area especially on the roads.

In meradia, the material, construction elements can create problems for the soil.Also various materials can be dumped in the soil if the workers are not careful which can affect the soil in that area.

Mitigation

In block c area during construction period, construction workers need to be trained and aware before the starting of construction,so that they don't pollute the area and don't dump the construction waste in that area. In the meradia area, during the construction period workers need to be careful so no harmful material ,chemicals mix with the soil.

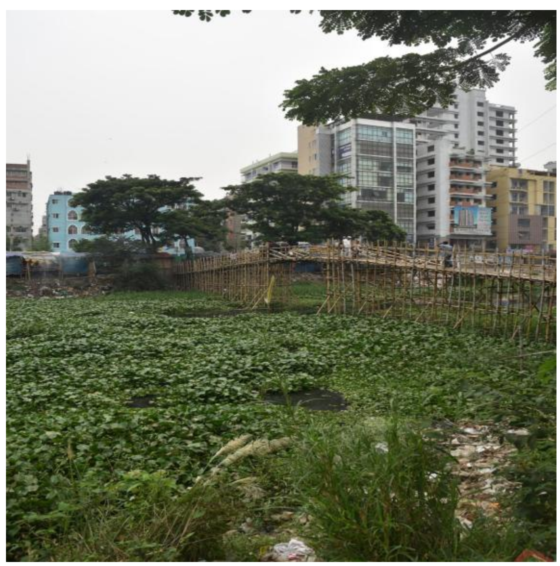


Figure: 1.7.1.3 Meradia area

Soil pollution causes chain reactions. It alters soil biodiversity, reduces soil organic matter,and reduces soil capacity to act as a filter. To save the area's soil people need to be more aware about waste management and stop the unnecessary dump waste on the road or into the canal side.To ensure that the government needs to make some strict rules.

1.7.2 Societal Impacts

The construction of an RCC pedestrian bridge in the described urban residential area over the canal is expected to have significant societal impacts. The presence of educational institutions, prayer places like mosques, and bustling markets in the vicinity highlights the importance of providing a safe and convenient crossing for pedestrians.

Enhanced Safety and Accessibility: The pedestrian bridge will improve safety by offering a designated pathway for students, residents, and visitors to cross the canal. It will help reduce the risk of accidents and enhance accessibility, particularly during peak hours when educational institutions are bustling with activity.

Promoting Active Transportation: The provision of a pedestrian bridge encourages walking and active transportation among individuals residing or working in the area. This contributes to healthier lifestyles, reduces dependence on motorized vehicles, and promotes sustainable urban mobility.

Community Integration and Connectivity: The bridge serves as a vital link, connecting different parts of the neighborhood. It enhances social integration by facilitating interactions between students, residents, and businesses in the area. It promotes a sense of community and fosters economic vitality by facilitating easy access to markets and commercial areas.

Alleviating Traffic Congestion: By providing a dedicated crossing for pedestrians, the bridge helps alleviate traffic congestion caused by pedestrian-vehicle conflicts. This can lead to smoother traffic flow, reduced travel times, and improved overall efficiency along the bypass road, benefiting both residents and businesses.

Urban Development and Aesthetics: The addition of a well-designed RCC pedestrian bridge can enhance the aesthetic appeal of the area, contributing to its overall urban development. It creates a landmark feature, showcasing the city's commitment to pedestrian-friendly infrastructure and enhancing its attractiveness for residents, visitors, and potential investors.

1.7.3. ***Navigation:***

The navigation system of the rampura canal is also an important criteria to select the appropriate site for the bridge location.To design a bridge, firstly we need to ensure that the boat and other water can move under the bridge properly. For block C area the canal width is approximately 110 ft. For the Meradia bazaar area the canal width is around 140 ft .Based on the size of the canal it would be good to select the block c site since the width is small compared to the meradia area.

1.7.4.Pedestrian Usage:

While doing the survey on both areas we get the idea of the pedestrian usage in those areas.Last september doing the survey on monday around 10 am at block c area the crowd was huge.The next day same time also we see the crowd was massive.
For meradia last September on Tuesday around 10am the crowd was also huge since there is a bazaar near the area.But by counting we noticed that block C bamboo bridge more people were using the bridge especially since there are offices, school near the area.

In summary, the construction of an RCC pedestrian bridge in this urban residential area in **block c** over the canal will have significant societal impacts. It will improve safety, promote active transportation, foster community integration and connectivity, alleviate traffic congestion, and contribute to urban development and aesthetics. The bridge will serve as a vital infrastructure element, positively influencing the daily lives and experiences of individuals within the neighborhood and beyond

1.8 PROJECT SCHEDULE

Month			May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Task	1	AASHTO Code Analysis													
	2	ETABS Learning													
	3	Site Visiting													
	4	Soil Report Analysis													
	5	Architectural Design Analysis													
	6	Start Report Writing													
	7	Compare Two Model at ETABS													
	8	Apply Load at ETABS													
	9	Load Analysis													
	10	Pile and Pile Cap Design													
	11	BOQ Calculation													
	12	Drafting and Drawing													
	13	Add All Data at Report													

CHAPTER - 2
ANALYSIS AND DESIGN

2.1 DESIGN CONSIDERATION

2.1.1 Material Properties

In the design and calculation of our pedestrian bridge, we have chosen a concrete strength of f'c = 6000 psi to ensure structural integrity and stability. This high-strength concrete will provide the necessary load-bearing capacity for both the substructure and superstructure of the bridge. For structural purposes, we have selected steel with a strength of 60000 psi (fy). Through careful optimization and calculations, we have determined the most suitable steel type to meet the specific requirements of the design.

To enhance the bridge's performance and accommodate movements, rubber bearings are employed. These rubber bearings offer flexibility and resilience, allowing the bridge to adapt to varying loads and environmental conditions.

Table: 2.1 Materials Properties

Material	Strength	Purpose	Application
Concrete	f'c = 6000 psi	Substructure	Foundation, Piers
Concrete	f'c = 6000 psi	Superstructure	Deck and Girder
Steel	f_y = 6000 psi	Superstructure & Substructure	Reinforcement
Rubber Bearing	N/A	Substructure & Superstructure	Bridge Movement
Steel Shapes	N/A	Superstructure	Railing System

Concrete	f'c = 6000 psi	Substructure	Foundation, Piers

2.1.2 Loading and Boundary Condition

Dead loads are those loads that are permanently applied to the structure. For the pedestrian bridge that is being designed, there are three sources for the dead load:

- The weight of the concrete deck.
- The weight of any railing/supports on the side of the walkway.
- The self weight of the structure.

Our group decided to use normal weight concrete for the decking which has an average weight of 150 pcf. Since the deck will be made from pre-cast concrete, once the bridge is built. On the site some kind of overlay will need to be added in order to allow for the bridge to have a smooth, continuous surface. For this, the contractor may decide to coat the top of the concrete with an overlay, so an additional load of 10 psf has been added to take this overlay into account. In addition to the load from the deck, there was also a 90 psf load applied on whole bridge. The railing/fencing load was transferred to the structure by a user defined load of 90 plf on the edge beams that support the concrete deck.

The group has calculated the dead load of the superstructure and substructure manually. Every specific weight of the structure has been calculated in the chapter. The basic theorem for calculating the dead load of the structure is to calculate and shape the geometrical condition of the structure and multiplying it with the unit weight of the material used per unit.

According to the AASHTO LRFD Bridge Design Specifications, dead loads for pedestrian bridges should include the self-weight of the bridge components, such as the deck, beams, and supporting structures. These dead loads are typically calculated based on the unit weights of the materials used in construction.

The specific specification related to live load for pedestrian bridges is the "AASHTO LRFD (Load and Resistance Factor Design) Pedestrian Bridge Live Load Specification" or AASHTO LRFD Pedestrian Guide Specification.

The AASHTO LRFD Pedestrian Bridge Live Load Specification categorizes live loads based on the area type. Some common area categories and their associated live load requirements may include:

Category A: This category includes areas with low pedestrian traffic such as the trails, parks or residential areas with limited pedestrian movement. For this category live has specified as 50 psf
Category B: This category includes moderate pedestrian traffic such as the sidewalks, urban areas and shopping plazas. For this category live has specified as 75 psf
Category C: This category includes the area with institutional building, high pedestrian traffic all day long, commercial areas as well. For this category live has specified as 100 psf
Category D: Stadium entrances, convention centers or areas with large crowds with high traffic. For this category live has specified as 150 psf

The project area we have selected is with an Institutional case and side wise it is with the commercial movements as well. And as mentioned in the previous chapter the area we have selected for the pedestrian bridge project is urban residential area on both sides of the canal. From the overall finding and understanding we have selected the bridge loading condition will be Category C as per the AASTHO and LRFD.

Superimposed Dead Load: It refers to additional permanent loads applied to the structure, such as the weight of wearing courses or finishes. In this case, the superimposed dead load is specified as 38 psf. These loads are considered not to be permanent and can be changed over time.

Now, let's discuss the load plan for different loads,

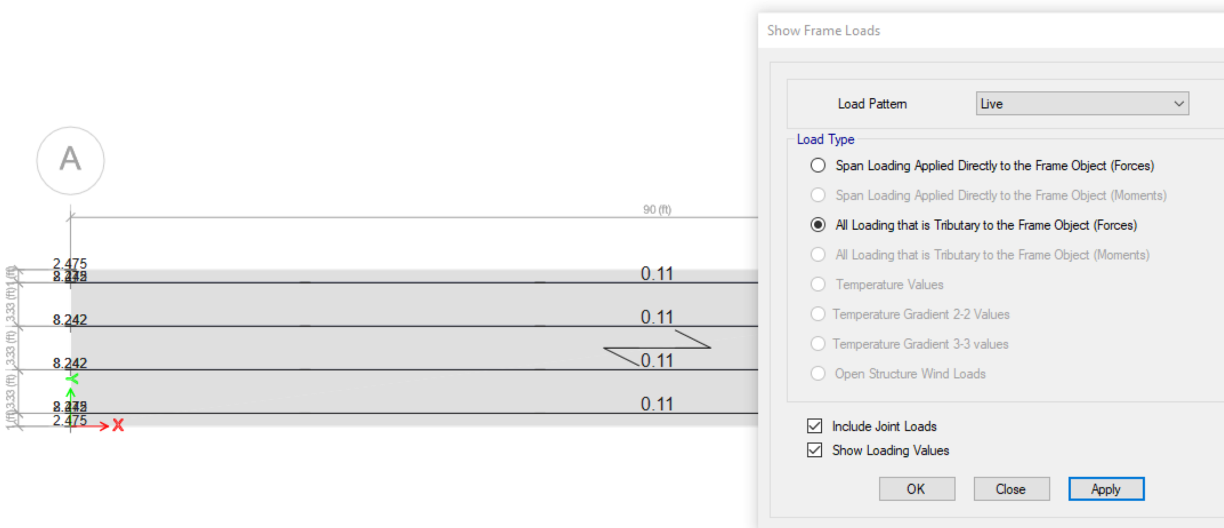


Figure 2.1 : Girder Frame live load

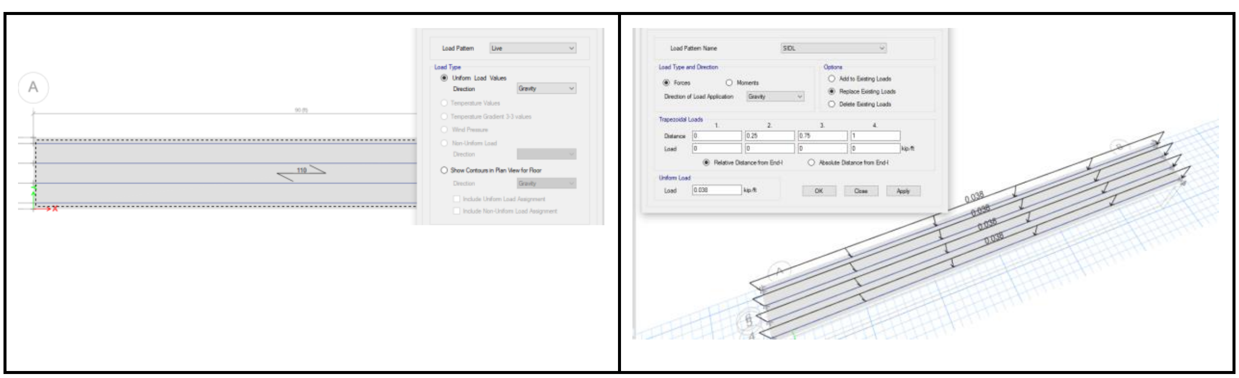


Figure 2.2 : Slab Shell load application

The slab and girders of the pedestrian bridge have been designed with a live load of 110 psf and a superimposed dead load (SIDL) of 38 psf. These load values have been input into the software, with the frames representing the supporting girders. This design approach ensures the structural integrity and safety of the bridge, considering the anticipated pedestrian loads and additional self-weight of the components.

Boundary conditions assumed in the analysis of the structure:

Boundary conditions refer to the constraints imposed on the structure's supports to simulate its interaction with the surrounding environment. Common boundary conditions include fixed supports, pinned supports, roller connections, and hinge connections.

In the case of the girders' end supports, two different connection systems are mentioned: Roller Connection System and Hinge Connection System. The specific boundary conditions provided by these connection systems will determine how the girders are restrained at their ends. A roller connection allows for horizontal movement and rotation, while a hinge connection allows for rotation but no horizontal movement.

The analysis of the structure will depend on the type of support provided by these systems and how they interact with the loads applied. The structural engineer performing the analysis will consider these boundary conditions to calculate the internal forces and stresses in the bridge components and ensure the structure's stability and integrity.

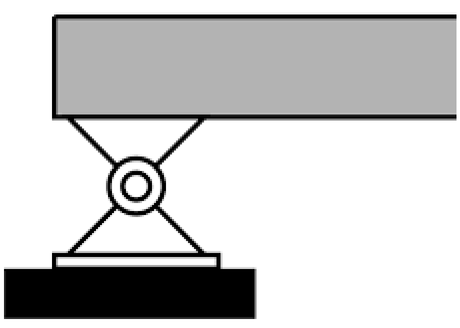


Figure 2.3 : Roller Supports

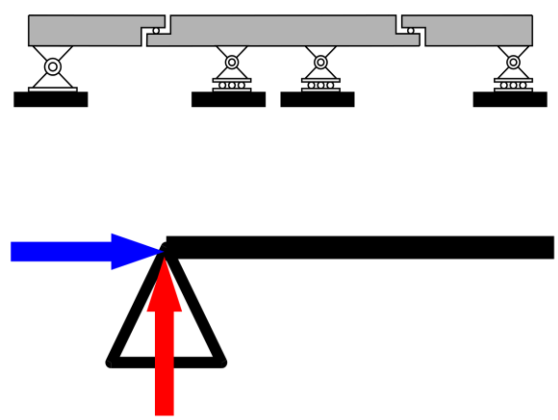


Figure 2.4 : Hinge Supports

2.1.3 Load Combination

According to LRFD Bridge design specification **from table 3.4.1-1 and table 3.4.1-2** load factors for the weight of the structure DC and DW, shall not be taken to be less than 1.25. So, we are going to assume for dead load factored 1.25 and for DW 1.5. For pedestrian live load the factor shall be 1.75

Names	Types
Dead	Linear Static
Live	Linear Static
SIDL	Linear Static

Table 2.2 : Load Case Definitions - Summary

Name	Type	Is Auto	Load Name	Factor
FDL	Linear Add	No	DL	1.25
FDL			SIDL	1.5
FDL			LL	1.75
UFDL			DL	1
UFDL			SIDL	1
UFDL			LL	1

Table 2.3 : Load Combination Definition

2.2 PRELIMINARY DESIGN

In response to the requirements set forth by Eastern Housing Limited, our group has developed a series of design concepts for a pedestrian bridge spanning approximately 100 feet across a canal. In order to ensure the feasibility and viability of our concepts, we have taken into account several key considerations outlined by Eastern Housing Limited, as follows:

a. Bridge Location, Formation Level, and Height:

Our proposed bridge location, formation level, and height have been carefully determined with a comprehensive analysis of all related issues. Analyzing the area of the project we have acquainted with a 90 ft long span bridge with no piers. We have taken into consideration factors such as navigation issues, hydrological considerations, and the aim to maximize pedestrian usage. By carefully evaluating these aspects, we aim to provide a bridge that not only meets the functional requirements but also addresses the concerns surrounding the canal.

b. Safety and Serviceability:

Ensuring the safety and serviceability of the bridge is of paramount importance. While we acknowledge that a complete assurance can only be provided upon the completion of the detailed design, we assure Eastern Housing Limited that we have incorporated all applicable codes and standards in our preliminary design. Specifically, we have utilized the guidelines established by the American Association of State Highway and Transportation Officials (AASTHO) to ensure that our bridge adheres to industry best practices in terms of safety and serviceability.

c. Unique Architecture and Aesthetic Appeal:

We understand the significance of creating a bridge that stands out and enhances its surrounding environment. To this end, we have given careful consideration to the architecture and shape of the bridge. Our design concepts aim to offer a unique and visually appealing structure that will become an iconic landmark in the area. By leveraging innovative design elements and incorporating feedback from Eastern Housing Limited, we are confident in our ability to deliver a bridge that is both aesthetically pleasing and architecturally distinctive.

d. Cost-Effective Structural Design:

In line with Eastern Housing Limited's requirement for a cost-effective solution, we have prioritized optimizing the structural design of the pedestrian bridge. By utilizing our expertise in structural engineering and considering factors such as material selection, construction techniques, and efficient use of resources, we are committed to delivering a bridge that not only meets the functional requirements but also remains within the allocated budget. Through careful analysis and evaluation, we aim to achieve an optimal balance between cost-effectiveness and structural integrity.

In conclusion, our preliminary design concepts for the pedestrian bridge over the 100' canal address the aforementioned requirements specified by Eastern Housing Limited. While the ultimate assurance of safety and serviceability will be provided upon completion of the detailed design, we assure Eastern Housing Limited that we have employed industry-standard codes and practices in our preliminary design.

Additionally, we have placed great emphasis on the unique architecture and aesthetic appeal of the bridge while optimizing its structural design to ensure cost-effectiveness. We are confident that our proposed design concepts will fulfill the vision set forth by Eastern Housing Limited and create a remarkable pedestrian bridge that seamlessly integrates functionality, safety, and visual elegance into its surrounding landscape.

For our preliminary design, we have considered two concepts: a 4-girder bridge system and a 2-girder bridge system. At this initial stage, both concepts will have identical cross-sections for the girders. However, should the analysis results indicate the need for design adjustments, we will optimize the bridge's cross-sections and girders accordingly.

To ensure accuracy, we have manually calculated the dead load, carefully determining all moments and shears. Additionally, we have calculated both factored and unfactored loads. Employing the ETABS software, we conducted a thorough analysis to obtain precise results. This integrated approach allowed us to gather comprehensive data, facilitating the development of an informed and effective solution.

Figure 2.5: Concept Bridge 3D Model

By considering various load scenarios and utilizing advanced software analysis, we have established a foundation for further design optimization. Our focus remains on ensuring structural integrity, safety, and adherence to applicable codes and standards. As we progress, we will incorporate the analysis results into our design, allowing us to refine and enhance the bridge's performance and functionality. Through this iterative process, we are confident in our ability to deliver a pedestrian bridge that meets all required criteria and provides a reliable, cost-effective solution.

2.2.1 Design Concept 1:4 Girders Bridge system

Our group has completed the calculation of all the geometric shapes involved in Design concept 1 and Design concept 2, for the bridge. Subsequently, we have determined the dead load, which includes the weight of the structure itself as well as the individual weights of other components. The self-weight specifically encompasses the load of the superstructure and the railing posts, both of which have been taken into careful consideration during our analysis.

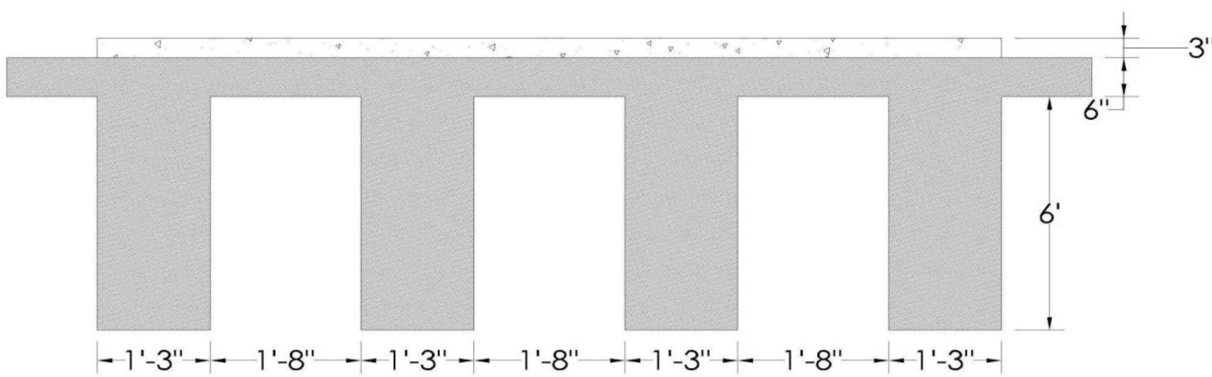


Figure 2.6: Dimensions of the design concept 1

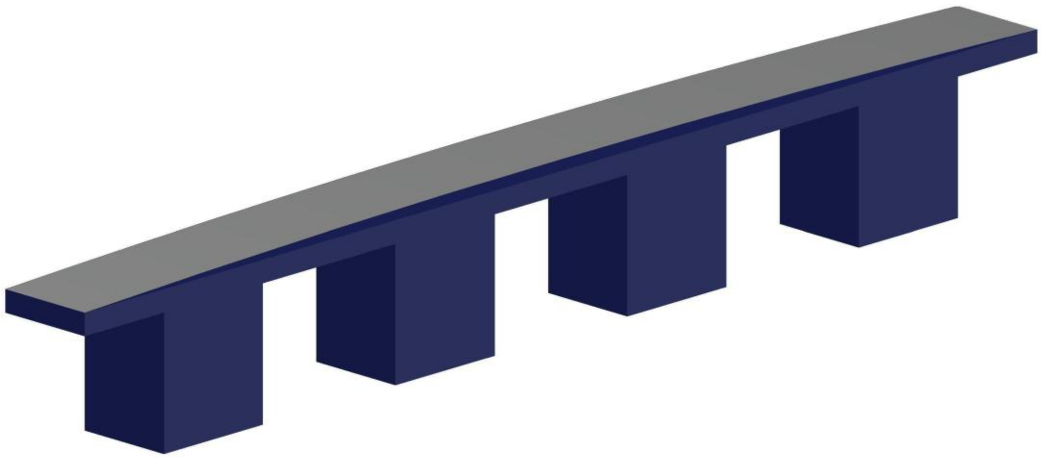


Figure 2.7: 3D Model of First Concept 4 Girders Bridge System

Our group has successfully developed the conceptual drawing utilizing the industry-standard AutoCAD version 2021. To advance our design process, we are now proceeding to incorporate various loads and additional structural elements within the renowned ETABS 20.0.0 software. This integration allows us to conduct a thorough analysis and pursue optimization, ensuring the utmost precision and efficiency in our bridge design.

Following the application of loads to the bridge system, we are eagerly anticipating the comprehensive results that will guide our design concepts. The figure illustrates the implementation of a 110 kips load on the frame, which aligns with the specified dimensions provided earlier. Notably, these frames correspond to the girders within the bridge structure, meticulously designed to ensure optimal performance.

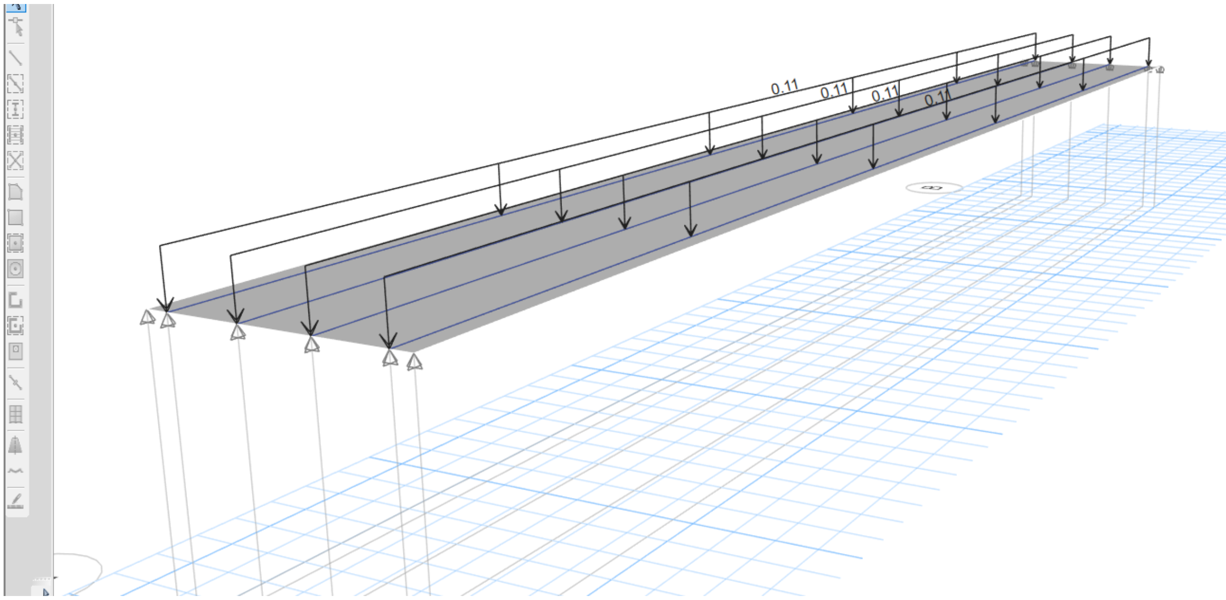


Figure 2.8: Live load application into girder frames

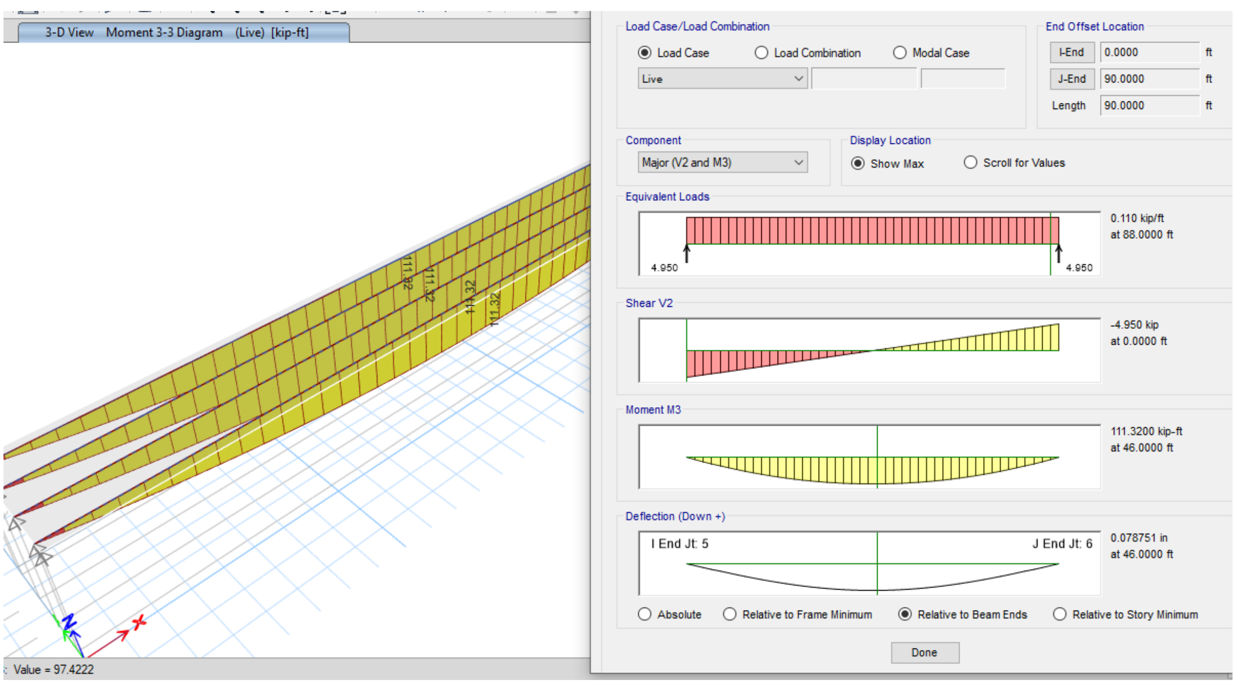


Figure 2.9 : Girder frame responses for Live load cases

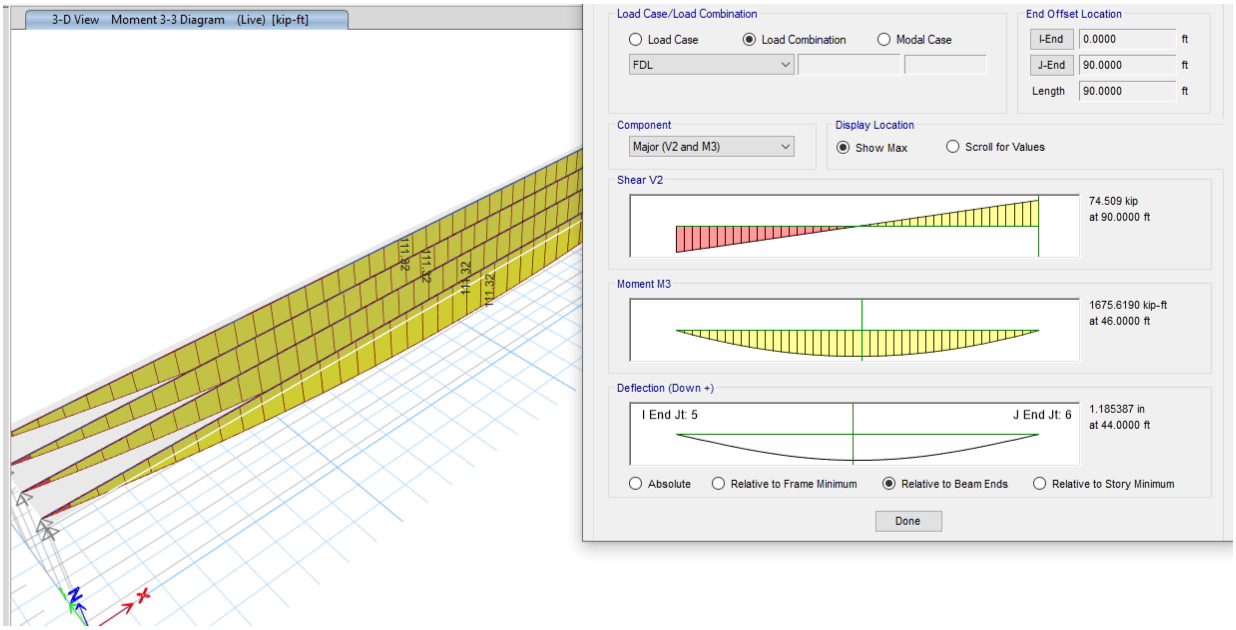


Figure 2.10: Girders responses for the Factored Dead Load

2.2.3 Design Concept 2 : 2 Girders Bridge system

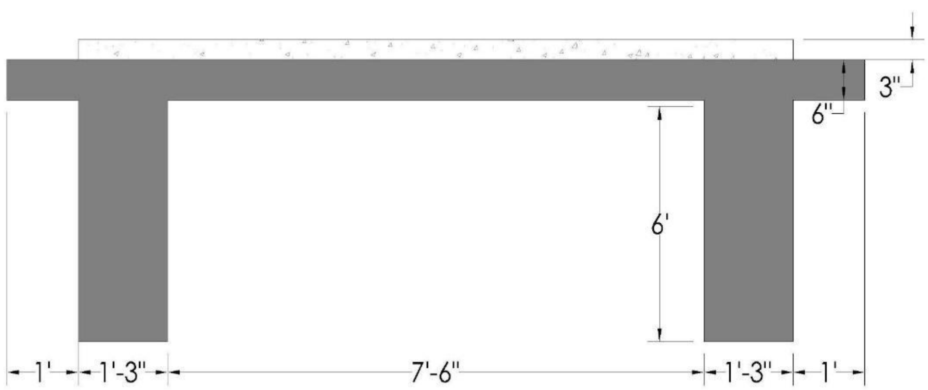


Figure 2.11: Dimensions of the design concept 2

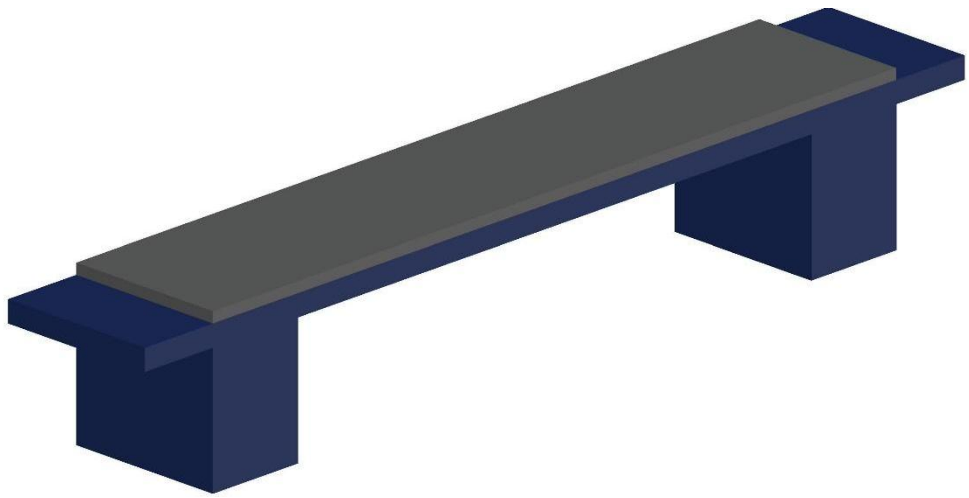


Figure 2.12: 3D Model of First Concept 2 Girders Bridge System

Design Concept 2 incorporates a configuration with two girders positioned below the deck, maintaining the same dimensions as the previous girder system. Notably, the center-to-center distances between the girders have been adjusted in this concept.

To obtain comprehensive insights, further analysis results will be obtained, revealing crucial answers regarding the structural performance, load distribution, and overall efficiency of Design Concept 2. These results will play a pivotal role in evaluating the viability and suitability of this configuration for the intended bridge project. The analysis will encompass factors such as deflection, stress distribution, and overall stability to ensure compliance with industry standards and the specific requirements outlined by the project stakeholders.

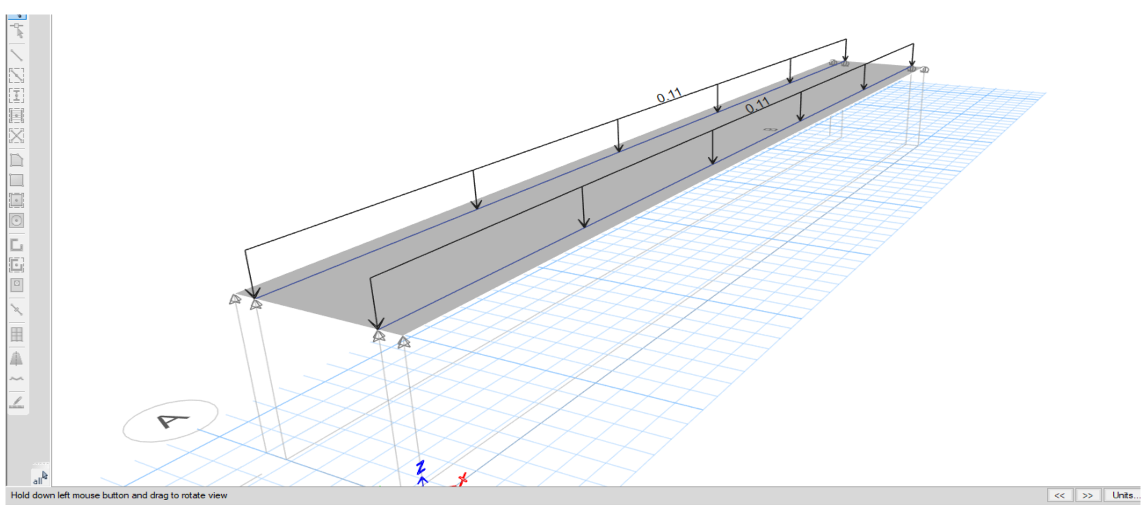


Figure 2.13: Live load application into the design concept

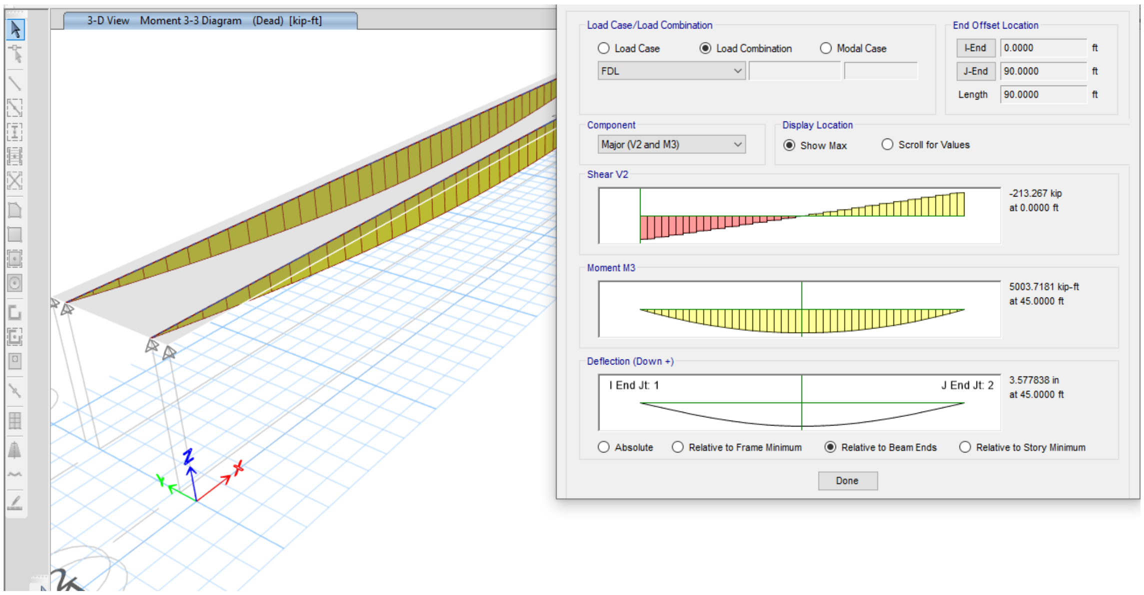


Figure 2.14: Girder frame responses in different load cases

2.3 ANALYSIS OF ALTERNATE SOLUTIONS

	ETABS		ETABS			ETABS	
	Moments M3 K/ft		Shear V3 k/ft			Deflection (in)	
Load Cases and Combination	4 Girders	2 Girders	4 Girders	2 Girder		4 Girders MS	2 Girders MS
				ES	MS		
FDL	1675.61	3942	74.5	213.26	-213.26	1.18	3.58
Dead Load	1138.5	1735	50.6	77.828	-77.8	.027	1.29
Live Load	111.32	773	-4.95	32.54	-32.54	.07875	.55

Superimposed Dead	38.45	267	1.7	39.351	-39.351	.0272	.67

Table 2.4: Etabs Results

Findings: After conducting the analysis, we have obtained noteworthy findings for the two bridge systems under consideration: the 4-girder system and the 2-girder system. The deflection results, expressed in inches, provide crucial insights into the structural performance of each system.

For the factored load, the 4-girder system exhibits a deflection of approximately 1.18 inches, while the 2-girder system displays a significantly higher deflection of 3.58 inches. In terms of the dead load, the 4-girder system demonstrates a deflection of 0.027 inches, whereas the 2-girder system experiences a much larger deflection of 1.29 inches. Furthermore, for the live load scenario, the 4-girder system indicates a deflection of only 0.0787 inches, while the 2-girder system reveals a noticeably higher deflection of 0.55 inches.

Based on these results, it is evident that the 4-girder system exhibits significantly lower deflections across all load scenarios compared to the 2-girder system. Consequently, we have determined that the 4-girder system provides superior performance in terms of minimizing deflections.

In light of this analysis, we conclude that the 4-girder bridge system is the preferable option in terms of generating lower deflections. These findings contribute crucial insights for the final design selection, ensuring the structural integrity, safety, and longevity of the bridge.

2.4 PERFORMANCE EVALUATION

Safety and Serviceability:

The applicable codes and standards, specifically the AASHTO LRFD Specification, have been followed to ensure the safety and serviceability of the bridge. This ensures that the bridge is designed and constructed to withstand the anticipated loads and usage.

Architecture and Attractiveness:

The architectural design of the bridge has been carefully considered to make it unique, attractive, and appealing. The bridge's shape and overall design have been tailored to create an aesthetically pleasing structure that stands out.

Structural Design Optimization:
The structural design of the bridge has been optimized to make it cost-effective. This means that the design achieves the required strength and functionality while minimizing material usage and construction costs. The cost analysis conducted confirms that the project remains within the budgetary constraints.

In summary, the following requirements have been met:

1. The bridge location, formation level, and height have been proposed to address navigation and hydrological issues while maximizing pedestrian usage.
2. Safety and serviceability requirements have been ensured by adhering to applicable codes and standards.
3. The bridge's architecture and shape are unique, attractive, and appealing.
4. The structural design has been optimized to achieve cost-effectiveness.

2.4.1 Validation Study

	Moments M3 K/ft		Shear V3 k/ft		
Load Cases and Combination	Manual	ETABS	Manual	ETABS	Deflection (in) ETABS
FDL	1683.23	1675.61	68	74.5	1.18

Dead Load	1012.5	1138.5	45	50.6	.027
Live Load	111.35	111.32	1.23	-4.95	.07875
Superimposed Dead	38.47	38.45	6	1.7	.0272

Tabel:2.5 Girders bridge manual calculation

	Moments M3 K/ft		Shear V3 ES k/ft			
Load Cases and Combination	Manual	ETABS	Manual	ETABS		Deflection (in) ETABS MS
				ES 90 ft	MS 45 ft	
FDL	3000	3942	137	213.26	-213.26	3.58
Dead Load	2025	1735	90	77.828	-77.8	1.29
Live Load	111.35	773	14.85	32.54	-32.54	.55
Superimposed Dead	38.475	267	1.2	39.351	-39.351	.67

Table: 2.6 Girders Bridge manual calculation

Upon careful comparison of the obtained results with the provided tables, we can confidently assert that our hand calculations align closely with the analysis results of the 4-girder bridge system. This congruence further validates the design of the 4-girder bridge, substantiating its compliance with the relevant AASHTO Code references.
By validating our calculations against the AASHTO Code requirements, we ensure that the 4-girder bridge design adheres to industry standards and guidelines. This validation process strengthens our confidence in the structural integrity, safety, and reliability of the selected design.

The close correlation between our hand calculations and the analysis results, coupled with compliance with the AASHTO Code, reinforces our assurance in the accuracy and suitability of the 4-girder bridge design. These findings provide essential support for our final design recommendation, ensuring that the bridge will meet the necessary structural performance criteria and withstand anticipated loads with efficiency and reliability.

We have performed manual calculations to further verify the design of the 4-girder bridge system. These calculations involved employing established engineering principles and equations to assess the structural behavior and performance of the bridge.

<u>Self-Weight</u>

ρCon. = 0.145 kcf =0.15 kcf
W-DC-S = (9/12)*3.55*0.15 = 0.4 k/ft
W-DC-G = (15/12)*(72/12)*0.15 = 1.125 k/ft
W-DC = (15/12)*4*0.15 = 0.67k/ft

So, Assume Dead Load, DL = 1 ksf

<u>Wearing Surface</u>

Assume for tiles, load= 38psf = 0.038 k/ft
ρDW. = 0.15 kcf
W-DW = (3/12)*3.55*0.15 = 0.133 k/ft

<u>Un-factored Moments</u>

M-DC- MS = $(wl^2/8) = (1/8)*1*90^2$ = 1012.5 k/ft
M-DC-QS = [1*90*(1/2)]*(90/4) –[1*(90/4)]*(90/8) = 760 k/ft

M-DW-MS = $(1/8)*0.038*90^2$ = 38.475 k-ft
M-DW-QS = [0.038*90*(1/2)]*(90/4) –[0.038*(90/4)]*(90/8)
= 28.8 k-ft

<u>Live load</u>: Pedestrian live load= 110 psf

Live Load, As per the AASHTO LRFD Bridge Design. The Bridge design live load depended on the category of that place where the bridge will be constructed,

<u>Category C: 110 psf (5.31 Kpa)</u>

AASHTO LRFD (American Association of State Highway and Transportation Officials Load and Resistance Factor Design).

For a deck girder bridge with girder spacing less than or equal to 6 feet, AASHTO LRFD recommends the following distribution factors:

Interior Girder: 0.60
Exterior Girder: 0.40

Using these distribution factors, we can calculate the live load moment for mid-span and quarter-span as follows:

Live Load Moment at Mid-Span
The live load moment at mid-span with distribution factors can be calculated as:

M = (0.60 x WL^2)/8 + (0.40 x WL^2)/8

Where,
W = Live load intensity in psf (given as 110 psf)
L = Span length of the bridge in feet (given as 90')

Substituting the given values, we get:
M = (0.60 x 110 psf x (90 ft)^2) / 8 + (0.40 x 110 psf x (90 ft)^2) / 8
M = 65,610 ft-lb + 43,740 ft-lb

Therefore, the live load moment at mid-span with distribution factors is 109,350 ft-lb, which is the same as the live load moment without distribution factors.

Live Load Moment at Quarter-Span
The live load moment at quarter-span with distribution factors can be calculated as:

M = (0.60 x Wl^2)/16 + (0.40 x Wl^2)/16

Where,
W = Live load intensity in psf (given as 110 psf)
l = Distance from the quarter-point to the support in feet

To find the distance from the quarter-point to the support, we can use the following equation:

l = (1/4) x L - (1/2) x S
Where,
L = Span length of the bridge in feet (given as 90')

S = Girder spacing in feet (given as 1.67'')

Substituting the given values, we get:

l = (1/4) x 90 ft - (1/2) x 1.67 ft
l = 21.67 ft

Substituting the value of l and W, we get:

M = (0.60 x 110 psf x (21.67 ft)^2) / 16 + (0.40 x 110 psf x (21.67 ft)^2) / 16
M = 16,346 ft-lb + 11,085 ft-lb

Therefore, the live load moment at quarter-span with distribution factors is 27,431 ft-lb, which is very close to the live load moment without distribution factors (27,430 ft-lb).

Live Load Moment at Mid-Span:(MS)	Live Load Moment at Quarter-Span:(QS)
The live load moment at Mid-span is 109,350 ft-lb. To convert this value into kip-ft, we can divide it by 1000 (1 kip-ft = 1000 ft-lb). 109,350 ft-lb / 1000 = 111.35 kip-ft (rounded to four decimal places) Therefore, the live load moment at mid-span in kip-ft is 111.35 kip-ft.	The live load moment at quarter-span is 27,430 ft-lb. To convert this value into kip-ft, we can divide it by 1000. 27,430 ft-lb / 1000 = 29.43 kip-ft (rounded to four decimal places) Therefore, the live load moment at quarter-span in kip-ft is 29.43 kip-ft.

Factored Moments
Mstrength-I-MS = 1.25 M-DC+1.5 M-DW+1.75M-LL=
1.25*1012.5+1.5*148.5+1.75*111.35= 1683.2375 k-ft
M-strength-I-QS = 1.25M-DC+1.5M-DW+1.75M-LL = (1.25*760) + (1.5* 95) +(1.75*29.43) = 1144.0025 k-ft

2.4.2 Serviceability Performance

The assessment of serviceability performance involves analyzing the deflection behavior of the bridge under various load cases and determining the extent to which it approaches or exceeds the deflection limits specified by the AASHTO Code and other relevant codes.

By subjecting the bridge to different load scenarios, including dead load, live load, and other applicable loads, we can evaluate the deflection response at critical sections of the structure. This analysis allows us to assess the bridge's compliance with deflection limits set by industry standards.

Through careful calculations and simulations, we quantify the deflections induced by each load case and compare them to the deflection limits prescribed by the AASHTO Code and other applicable codes. This comparison provides insights into how close the bridge's deflections are to the established limits and determines whether any adjustments or design modifications are necessary.

By ensuring that the bridge's deflections remain within acceptable limits, we guarantee the structural integrity, functionality, and overall serviceability of the bridge. This analysis contributes to the overall assessment of the bridge's performance, ensuring that it meets the deflection criteria outlined in the AASHTO Code and other relevant codes.

Ultimately, the analysis of deflection performance provides essential information to ensure the bridge's reliability, durability, and user comfort throughout its service life.

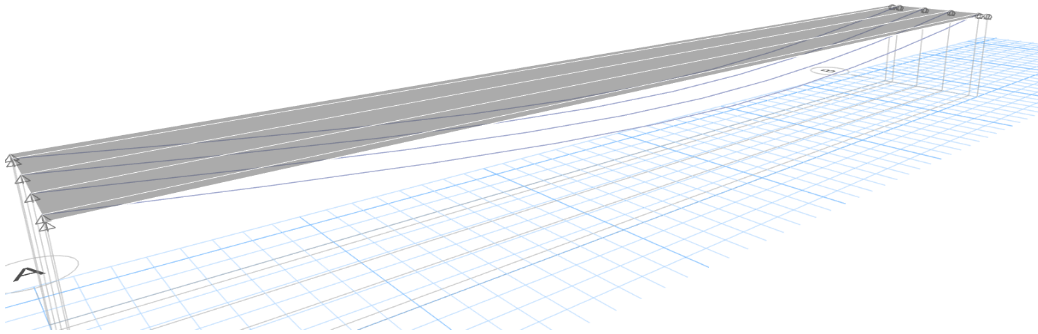


Figure: 2.15 Plan view of the deflection

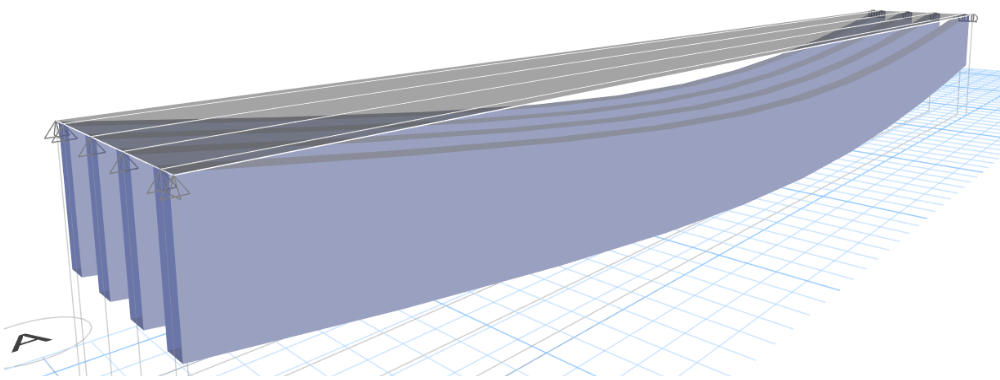


Figure: 2.16 Actual deflection on the girders

In adherence to the AASHTO Code, which governs the design of our bridge, we have considered a bridge length of 90 feet and the application of a uniformly distributed live load of 110 kips on the girders. Based on the prescribed criteria, we can determine the deflection limits to ensure structural integrity and safety.

According to AASHTO, for live loads, the deflection limit is typically set at L/800, where L represents the span length of the bridge. In our case, this equates to a deflection limit of 0.1125 feet or approximately 1.35 inches. Additionally, the AASHTO Code specifies a deflection limit of L/1000 for total loads, resulting in a maximum deflection of 0.09 feet or approximately 1.08 inches for our bridge.

By adhering to these deflection limits, we aim to ensure that the bridge remains within the acceptable range of deflection, maintaining its structural integrity and providing a safe passage for users. Further analysis and design optimization will be conducted to meet the stringent requirements outlined by the AASHTO Code for beam deflection, guaranteeing a robust and reliable bridge structure.

For live load deflection:

Deflection limit = (90 ft) / 800 = 0.1125 ft = 1.35 inches

For total load deflection:

Deflection limit = (90 ft) / 1000 = 0.09 ft = 1.08 inches

	Moments M3 K/ft		Shear V3 k/ft		
Load Cases and Combination	Manual	ETABS	Manual	ETABS	Deflection (in) ETABS
FDL	1683.23	1675.61	68	74.5	1.18
Dead Load	1012.5	1138.5	45	50.6	.027
Live Load	111.35	111.32	1.23	-4.95	.07875
Superimposed Dead	38.47	38.45	6	1.7	.0272

Table: 2.7 Software Calculated Deflections

During the evaluation of the factored load deflection, represented as FDL, we observed a deflection of 1.18 inches for the 4-girder bridge system. Remarkably, this deflection closely aligns with the deflection limit of 1.08 inches specified by the AASHTO Code. The similarity between the calculated deflection and the code's stipulated limit reinforces the adequacy of the design concept.

Furthermore, the live load deflection range, with a value of 1.35 inches, showcases that our bridge design's live load deflection is only 0.07875 inches. This deflection is well within the specified limits, further affirming the suitability of the chosen design concept.

Based on these findings, we can confidently recommend the 4-girder bridge system for the final design. Its factored load deflection and live load deflection fall comfortably within the permissible limits established by the AASHTO Code. This adherence to the code's requirements ensures the structural integrity and safety of the bridge.

The alignment of our calculated deflections with the AASHTO Code's specifications provides strong validation for the selected design concept. This outcome underscores the meticulousness of our analysis and the rigorous adherence to industry standards.

In summary, the factored load deflection and live load deflection of the 4-girder bridge system remain well within the limits prescribed by the AASHTO Code. These findings solidify the feasibility and suitability of the design concept for the final bridge design, assuring structural integrity and reliable performance under anticipated loading conditions.

2.5 FINAL DESIGN

Based on our analysis and comparison with the deflection limits prescribed by the AASHTO Code, we have derived the following results:

For live load deflection, the calculated deflection limit is 0.1125 feet (1.35 inches), while the AASHTO limit is 0.07875 feet (0.945 inches). Our software calculations confirm that the deflections obtained from the model are within the permissible range defined by the AASHTO Code.

Similarly, for total load deflection, the calculated deflection limit is 0.09 feet (1.08 inches), whereas the AASHTO limit is 0.118 feet (1.416 inches). Once again, our software analysis confirms that the deflections fall within the acceptable range specified by the AASHTO Code.

Based on these observations, we can conclude that there is no need to make any changes to the frame section or other properties of the bridge. The analysis results indicate that the bridge design meets the deflection criteria set forth by the AASHTO Code. This finding ensures that the bridge structure will maintain its structural integrity and safety under the given live load and total load conditions.

It is important to note that these results have been obtained from the ETABS modeling software and validated against the deflection limits outlined in the AASHTO Code. However, further comprehensive analysis and review by qualified structural engineers are recommended to ensure the overall structural adequacy of the bridge design.

2.5.1 Girder Design

Design for flexure At the Mid-Span

M-strength-I Pos = 1683 k-ft = 20196 k-in

deff = 72 – 1.5 – 0.5 – 1.5*(14/8) – 1.5*(14/8) = 64.75”

Trial-1 (Assume, a=9”) As = 6.20 in^2 a = 1.71 in [T-beam assumption ok]	Trial-2 (Assume, a=1”) As = 5.85 in^2 a = 1.61 in (OK)

Provide, 6 bars of #9 bars = 6 in^2 (#9 bar Cross Section Area = 1 in^2)

As = (M-strength)/ .9*fy*(deff - a/2)
a = As x Fy /.85*f’c*bi

We don’t need the same amount of steel throughout the length of the beam. At the mid-span, the bending moment is maximum and we need the maximum steel area there. As we move towards the support, the requirement of steel area gradually decreases.

Design for flexure at the Quarter Span

M-strength-I Pos = 1144.0025 k-ft = 13728.03 k-in

deff = 71 – 1.5 – 0.5 – 1.5*(7/8) – 1.5*(7/8) = 66.625”

Trial-1 (Assume, a=9”) As = 4.09 in^2 a = 1.13 in [T-beam assumption ok]	Trial-2 (Assume, a=1”) As = 3.84 in^2 a = 1.06 in (OK)

Provide, 5 bars of #8 bars = 3.95 in^2

Design for Shear At End-Span

V-strength-I End Span = Vu = 68 kip

For the maximum dv,

- d-a/2 = 67 – .911 /2 = 65.9195”
- 0.9*66.375 = 59.7375”
- 0.72*71 = 51.12”

Selected, dv = 66”

S= Avfy/(0.9Vu)
where,
S is the spacing between the stirrups

- Av is the area of transverse reinforcement per unit length of the girder
- fy is the yield strength of the transverse reinforcement
- Vu is the factored shear force on the girder
- Ø is the resistance factor, which is taken as 0.75 for shear in reinforced concrete members according to the AASHTO LRFD Bridge Design Specifications.

Assuming, a transverse reinforcement of #4 stirrups with a yield strength of 60 ksi and an area of 0.2 square inches per foot of girder length,

we have,
Av = 0.2 in^2/ft * (12 in/ft) = 2.4 in^2/ft

fy = 60 ksi
Vu = 68 kips (V-strength-I)

Plugging in the values, we get:

S= (2.4 in^2/ft * 60 ksi)/(0.9 * 0.75 * 68 kips) = 3.13 inches

Therefore, the spacing for the selected value of dv = 66 inches is 3.13 inches.

<u>Maximum Spacing</u>	<u>Minimum Reinforcement</u>
If, Vu (stress)< 0.125f'c => [68/(0.9*15*67)] < 0.125*6 => 0.0751 < 0.75 okay. Therefore, Smax = 0.8dv or 24" = 0.8*66 or 24" = 52.8" or 24" And , 24" > 1.98" Okay	Av ≥ 0.0316*SQRT(f'c)*[(bvS)/fy] Av = 0.0316*SQRT(6)*[(15*1.98)/60] Av = 0.038 in^2 (Required) Provide, Av = 0.22 in^2 Okay. (Similarly, spacing also can be calculated.)

<u>Design for Shear At Quarter-Span</u>

V-strength-I Quarter span = Vu = 37 kip

For the maximum dv
d-a/2 = 66.375 –.911 /2 = 65.9195"
0.9*66.375 = 59.7375"
0.72*71 = 51.12"

Selected, dv = 66"
S= (2.4 in^2/ft * 60 ksi)/(0.9 * 0.75 * 37 kips) = 5.76 inches
Therefore, the spacing for the selected value of dv = 66 inches is 5.76 inches.

Maximum Spacing	Minimum Reinforcement
If, Vu (stress)< 0.125f'c => [37/(0.9*15*67)] < 0.125*6 => 0.040 < 0.75 okay. Therefore, Smax = 0.8dv or 24" = 0.8*63.75 or 24" = 51" or 24" And , 24" > 1.91" Okay	Av ≥ 0.0316*SQRT(f'c)*[(bvS)/fy] Av = 0.0316*SQRT(6)*[(15*1.91)/60] Av = 0.036 in^2 (Required) Provide, Av = 0.22 in^2 Okay. (Similarly, spacing also can be calculated.)

2.5.2 Structural Design

2.5.2.1 Design of Slab

Analysis of deck

Self-Weight

ρCon. = 0.145 kcf =0.15 kcf
WDC = (6/12)*1*0.15 = 0.075 k/ft
M-DC-POS = (1/10)*0.075*1.67^2 =0.0209 k-ft /ft
M-DC-NEG = (1/10)*0.075*1.67^2 = 0.02 k-ft /ft

Wearing Surface

ρDW. = 0.14 kcf
WDW = (3/12)*1*0.14 = 0.035 k/ft
M-DW-POS = (1/10)*0.035*1.67^2 = 0.00976 k-ft /ft = 0.01k-ft/ft
M-DW-NEG = (1/10)*0.035*1.67^2= 0.01 k-ft /ft

Live Load
M(P)=4.68 k-ft/ft
M(N) = 2.68 k-ft/ft

Factored Moments

M-strength-I Pos = 1.25MDC+1.5MDW +1.75MLL= 1.25*0.02+1.5*0.01+1.75*4.68= 8.23 k-ft /ft
M-service-I-Pos = MDC+MDW+MLL =0.03+0.01+4.68 = 4.72 k-ft /ft

M-strength-I-Neg = 1.25MDC+1.5MDW +1.75MLL = 1.25*0.02+1.5*0.01+1.75*2.68= 4.73 k-ft /ft
M-service-I-Neg = MDC+MDW+MLL =0.02+0.01+2.68= 2.72 k-ft /ft

Design of Deck-Design For Flexure

M strength-I Pos = 8.23 k-ft /ft = 98.76 k-in/ft

Design Basis, MU ≤ ØMn

Effective depth, deff(P) = 6”-1”-0.5*(7/8) = 5.4375” = 5.5”
Effective depth, deff(N) = 6”-2.5”-0.5*(7/8) = 3.9375” = 4.0”
β= 0.85
ρ0.005=0.85*0.85*(6/60)*(0.003/(0.003+0.005)) = 0.027=0.03

For Positive Moment

Trial-1 (Assume, a=3”)

As = 98.76/(0.9*60*(5.5-(3/2))) = 0.457 in^2

a = (0.46*60)/(0.85*6*12) = 0.45 in
Trial-2 (Assume, a=0.5”)

As = 98.76/(0.9*60*(5.5-(0.5/2))) = 0.348 in^2

a = (0.348*60)/(0.85*6*12) = 0.34 in OK
Check for net strain of steel,

Calculate, c = a/β= 0.34/0.85= 0.4,
calculate, ε= 0.003(d-c/c) = 0.003[(5.5-0.4)/0.4] =0.038> 0.005

So. Ø = 0.9 OK

Provide, #5 @ 10” c/c [(12*0.31)/0.348=10.68”]

For Negative Moment (Following the same procedure)
M strength-I Neg = 4.73 k-ft /ft = 56.76 k-in/ft

Trial-1 (Assume, a=3") As = 56.76/(0.9*60*(4-(3/2))) = 0.42 in^2 a = (0.42*60)/(0.85*6*12) = 0.4 in	Trial-2 (Assume, a=0.4") As = 56.76/(0.9*60*(4-(0.4/2))) = 0.28= 0.3 in^2 a = (0.3*60)/(0.85*6*12) = 0.29 in OK

Check for net strain of steel,

Calculate, c = a/β
where, c = a/β= 0.4/0.85= 0.47

ε= 0.003(d-c/c) = 0.003[(4-0.4)/0.4] =0.027> 0.005

So. Ø = 0.9, OK
Provide same as bottom bar, #5 @ 10" c/c

Check For Control of Cracking

[d =1 + 0.5*(5/8)=1.313"]

$\beta s = 1 + \frac{dc}{0.7(h - dc)}$

=1 + 1.313"/(0.7*(6-1.313)) = 1.3

γe = 0.75 [Class 2, appearance is important]

fss = M service-I Pos/ AsJd [Assuming Section is cracked, elastic]
As = 0.348 in2

ρ = 0.35/(12*5.5) = 0.005;
n = Es/Ec =6.5
k = sqrt[(0.005*6.5)2+2*(0.005*6.5)] – (0.005*6.5) = 0.33
j = 1- (0.33/3) = 0.89

fss = (4.72*12)/(0.348*0.89*5.5) = 33.24

Thus, $S \leq \frac{700\ \gamma e}{\beta s\ \ fss}$ - 2 dc
S = [(700*0.75)/(1.3*33.24)]– 2*1.313 = 9.4”

Need to revise the flexure design for control of cracking.
Provide, #5 @ 9” c/c

Design For Negative Moment (Top bar)
Similarly, design the deck for negative moment as well both for Flexure and Control of cracking. Here, provided #5 @ 9” c/c
Design of Longitudinal Reinforcement

For Top Rebar

As ≥ (1.3*12*6)/(2*(12+6)*60)
As ≥ 0.043 in2

[As should be between 0.11 to 0.6]

Final, As = 0.11 in^2
Provide, #3 @ 12” c/c [Spacing should minimum of 3h or 18”]

For Bottom Rebar
Actual percentage = 220/SQRT(1.67) = 170%
Selected percentage of rebar will be 67%
As = 0.67* 0.35 = 0.2332 = 0.23 in2
Provide, #4 @ 9” c/c

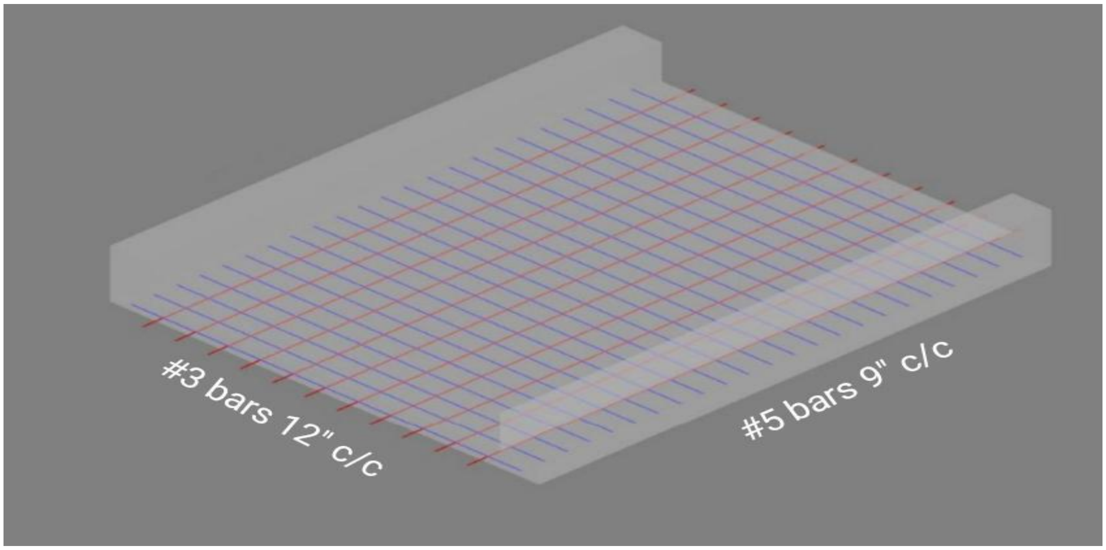


Figure: Slab reinforcement detail

2.5.2.2 Abutment Design

An abutment is a structural element that supports the ends of a bridge or any other elevated structure. Its primary function is to transfer the load from the superstructure (bridge deck) to the ground or foundation. The design of abutments is crucial for ensuring the stability, durability, and overall performance of the bridge. For our abutment Design:

Assume,

Abutment Height = 7.62m = 25ft [For pile cap to RL]

In our soil report we can choose abutment height.

Soil Lateral Load

Let, $\Phi = 30°$ [For Medium Sandy Soil]

So, $K_o = 1 - \text{Sin}30° = 0.5$

$P_h = 0.12 \times 25 \times 0.5 = 1.5\ K/ft^2$

Total $P = 0.5 \times 1.5 \times 1 \times 25 = 18.75$ K

So, $Y = \frac{18.75}{3} = 6.25$ ft

Now,

Check for Moment

For SFD and BMD calculation we can find Mu,

Mu = 20.1 × 6.25 = 125.6 K-ft/ft

Let, h = 36 inch

d = 36-1-1.5 × $\frac{8}{8}$

= 33.5 inch

Now, a = 1 inch

$A_s = \frac{Mu}{\Phi fy\,(d - \frac{1}{2})}$

$= \frac{125.6 \times 12}{0.85 \times (33.5 - \frac{1}{2})}$

= 0.9 inch2

Then, a = $\frac{As \times fy}{0.85 \times f'c \times b}$

$= \frac{1 \times 60}{0.85 \times 4 \times 12}$

= 1.32

Now, a = 1.32

As = 0.9

So, we use #9 bar

Spacing, S = $\frac{1x12}{0.9}$

= 10" c/c

So use #9 bar @10" c/c

Bar Cut Off

The bar cut-off length, also known as the development length, is an important consideration in the design of abutments. The bar cut-off length refers to the length of reinforcement bars that need to be embedded in the concrete beyond the critical section to ensure proper transfer of forces and to prevent premature failure of the structure.

Now,

$P_h = 1.5 \times 1.35 \times 1.25 = 2.53$ K/ft^2

$Mx = 0.5 \times 0.101x \times \frac{x}{3}$

$= 0.0168\ x^3$ K-ft

Mx total = 0.0168x3 × 12 = 0.2 x^3

Now,

M23 = $0.2 \times 25^3 = 3125 < 3140$ [Okey]

$\frac{3}{4}$ of this moment = $\frac{3140 \times 3}{4}$

= 2355 k-ft

Cut off point x = $\sqrt[3]{\frac{2355}{0.2}}$

= 23 ft

= (25-23) ft

= 5 ft

So, Cut first layer after 7ft about pile cap

Then, $\frac{1}{2}$ of this moment = $\frac{2355}{2}$

= 1177.5 K-ft

Cut off point, x = $\sqrt[3]{\frac{1177.5}{0.2}}$

= 18 ft

= (25 – 18) ft

= 7 ft

So, Cut 2nd layer after 12ft about the pile cap

Then,

$\frac{1}{4}$ of the moment = $\frac{2355}{4}$ K-ft

= 588.75 K-ft

So, location of bar cut off from strip, x = $\sqrt[3]{\frac{588.75}{0.2}}$ ft

= 14.3 ft

= (25-14.3) ft

= 10.7 ft

So, 3rd layer bar can be cut off = 13 ft from pile cap.

Check for Shear

Here,

$V_o = 1.5 \times 12 \times 0.5$

$= 9$ K

Now,

Vu = 9 x 1.35 = 12.15 K

Vc = $0.0316 \times 2 \times \sqrt{4} \times 12 \times 9.7$

= 14.7 K

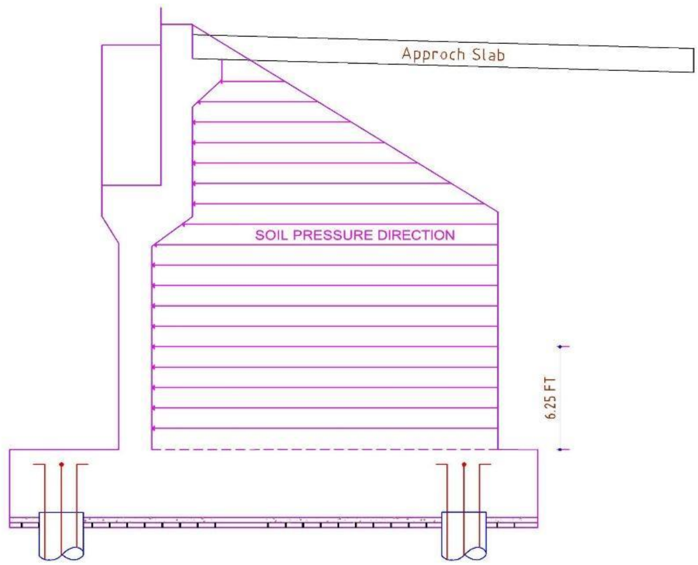
Now, ΦVc = 0.9 × 14.7

= 13.23 K

So, Vu < ΦVc [Okey]

2.5.2.3 Pile Cap Design

To calculate the number of piles required, we need to consider the ultimate bearing capacity. Let's break down the calculation step by step:



SECTIONAL ELEVATION OF WING WALL (SEC.1-1)
SHOWING REINFORCEMENT

Soil Load = 17.5 × 15 × 25 × 120

= 787500 lb

= 788 Kip

Live Load = 12 × 8 × 7

=7200lb

= 7.2 Kip

Abutment Wall Load = 12 × 3× 25 × 150

= 135000 lb

= 135 Kip

Pile Cap Load = 15 × 15 × 5 × 150

= 196875 lb

= 197 Kip

So, Total Load, = 788+ 7.2 + 135+ 197 = 1128 Kip

Given information in soil report:

Pile diameter: 750 mm

Pile length: 88 ft

Allowable carrying capacity: 2436 kN

= 487 Kip (with a safety factor of 2.5)

Note: We collect data for the soil report in borehole No. 3 and the hole is 27m. In this hole maximum ultimate bearing capacity is found.

Number of piles required = $\frac{Total\ \ load}{Ultimate\ \ bearing\ \ capacity}$

$$= \frac{1128}{487}$$

$$= 2.31 \approx 3 \text{ nos}$$

Since we can't have a fraction of a pile, we would typically round up the number of piles required to the nearest whole number. Therefore, in this case, we would require a minimum of 4 piles.

Punching Shear Stress:

Effective depth, d = 60"- 9"

= 51"

Factored Load, Vu = $\frac{FDL}{No\ of\ Pile}$

$$= \frac{(1.25\times797)+(1.75\times332)}{4}$$

= 394 Kip [For Single Pile]

Actual Bearing Capacity, ΦVb = $\Phi 4\sqrt{f'c} \times b_0 \times d$

$= 0.75\times4\times\sqrt{4}\times15.5\times4.25$

= 395.25 Kip

So, Actual Bearing Capacity is greater than Factored Load. [Pile Cap Depth is Ok]

Require Steel Bar:

We Know, As = $\frac{200}{fy} \times b\times d$

$= \frac{200}{60000} \times 12" \times 51"$

$= 2.04 \text{ inch}^2$

Use No 10 Bar in four layer

Spacing, S = $\frac{1.27x12}{2.04}$

$S = 7"$ c/c

So, Steel Bar required for pile cap is #10 bar @ 7" c/c.

2.5.2.4 Pile Calculation

Pile calculations are an important aspect of geotechnical engineering and foundation design. Piles are deep structural elements that transfer the loads from the superstructure to the underlying soil or rock strata. The calculation of piles involves several steps, including determining the load capacity, pile dimensions, and settlement analysis.

Require Steel Bar for Pile:

Lateral Force for 12"= $\frac{1}{2} \times \gamma\, h \times h$

$= \frac{1}{2} \times 120 \times 8 \times 29$

$= 13920$ lb

Total Force = $\frac{13920 \times 17.5}{4}$

= 60900 lb

= 70 Kip

Total Pile length = 88ft

Unsupported Pile length, L = 15D

$= 15 \times 2.48$

= 37.2 ft

So, we calculate Moment (M_u) for 37.2ft of pile.

$Mu = 70 \times 37.2$

= 2604 Kip-ft

Now, Reinforcement

Now, a = $\frac{As \times fy}{0.85 \times f'c \times b}$

$= \frac{As \times 60}{0.9 \times 4 \times 12}$

= 1.47 As

So, $A_s = \frac{Mu}{\Phi fy\,(d - \frac{1}{2})}$

$= \frac{2604 \times 12}{0.9 \times 60000 \times (5 - \frac{1.47 As}{2})}$

= 0.25

Use No 5 Bar

So, the Steel Bar required for the pile is Number 5 bar.

Spacing, S = $\frac{0.31 x 12}{0.25}$

= 10'' c/c

Table 6.3.11: Guidance of the minimum Reinforcing Steel for Bored Cast-in place Piles (BNBC) says for 750 mm Bored Cast-in place Pile can be use minimum number of steel bar is 10.

Lateral Reinforcement:

For Lateral Reinforcement we use #3 bar and pitch 0.1m

Dia of Helical Ring, n$\sqrt{C^2 + P^2}$

$= 272\sqrt{2.6^2 + 0.1^2}$

= 708 m

No of Lap = $\frac{Dia\ of\ Helical\ Ring}{Total\ Length\ of\ pile}$

$=\frac{708}{27}$

= 26.2 nos

Total Length of Steel Bar = 708 + 26.2×50×D

= 708 + 26.2×50×0.008

= 719 m

Note: Choose this bar dia use [Table 6.3.11: Guidance of the minimum Reinforcing Steel for Bored Cast-in place Piles (BNBC)]

2.6 DRAWING DETAILS

Drawing details are summarized at the end of the report in APPENDIX A.

2.7 USE OF MODERN ENGINEERING TOOLS

The design, modeling, simulation, and performance evaluation of our pedestrian bridge, we employed two key software tools: AutoCAD and ETABS. Here are a few common of problems ETABS in our project that we faced:

Complex geometry: In our bridges often have intricate and varying geometries, such as curved alignments and variable cross-sections. Modeling such geometries accurately can be challenging in ETABS. To overcome this, we can break down the geometry into simpler segments and use appropriate modeling techniques for each section. For example, in ETABS, we can create multiple frame objects to represent different sections of the bridge.

Load distribution: Our girder bridges require accurate load distribution analysis to determine the internal forces and design the reinforcement. Ensuring proper load distribution across the bridge model is crucial. In ETABS, we can use line loads or area loads and specify load patterns according to the design code requirements.

Reinforcement detailing: RCC long girder bridges require detailed reinforcement modeling, including bars, stirrups, and other reinforcement elements. ETABS provides limited reinforcement modeling capabilities, and it may be challenging to accurately represent all the required reinforcement in the model.

Here are a few common of problems AutoCAD in our project that we faced:

We have faced some problems while doing AutoCAD Drawing because it is very time consuming. Accurately representing the reinforcement detailing in AutoCAD can be time-consuming and prone to errors. Manual drafting of reinforcement bars, stirrups, and other elements can be challenging, especially when dealing with complex bridge sections. Consider using specialized reinforcement detailing software, such as Autodesk Revit, which provide tools specifically designed for reinforcement detailing. These tools can help automate the placement of reinforcement elements and ensure accuracy.

CHAPTER – 3

PROJECT PLANNING

3.1 GENERAL

Below the cost of all the materials are given in a tabular format:

3.2 BILL OF QUANTITIES OF STRUCTURAL DESIGN

PROJECT: RCC Pedestrian Bridge					
Bill of Quantity With Specifications and Costing					
Item No.	Description	Quantity	Unit	Rate	Amount
1	SITE PREPARATION				
1.1	Demolition of existing structure and removal of waste.	1	L.S	2,00000	2,00000
1.2	Layout and Marking Giving layout, providing center lines, setup local bench-mark pillars, etc. complete as per instruction of Engineer-in-charge.	250	Sqm.	100	25000
	Total Cost of Site Preparation				2,25000.0
2	SITE OFFICE & MOBILIZATION				

2.1	Mobilization Mobilization and cleaning site before commencing actual physical work and during contract period and demobilization after completion of the Works under contract accepted by Engineer. This work shall also covers clayey cleaning and clearing, cutting or filling, dressing the project area on and in the ground to an extent that all the events of works of the project can be executed smoothly in a working environment with a particular attention on safety and security in all respects, and to stockpile the end outcome to a place for disposal agreed by the Engineer, where, payments are to be based on ground area determined by the Engineer and be proportionate to the percentage progress of work under contract as a whole in all respects and approved by the Engineer.	195	Sq.m	180	35100.0
	Site office Engineer's site office of minimum 15 sqm plinth area with providing furniture, first aid box, safety helmet, level / theodolite, consumables, stationeries etc.	1	LS	2,0000 0	2,00000
2.2	SAFETY MEASURES Supply, installation and execution of safety measures and labor welfare facilities i.e. safety helmet, shoes, vests, first aid tool box, drinking water, toilet, safety barricade, temporary fencing etc. as specified in the general conditions of contract (clause 51).	1	LS	10000 0	100000
	Total Cost of Site office and Mobilization				335100.0
3	EARTH WORK				

3.1	Earth Excavation Earth works in excavation in all kinds of soil for foundation trenches including. layout, providing center lines, local bench-mark pillars, leveling, ramming and preparing the base, fixing bamboo spikes and marking layout with chalk powder, providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineer, subject to submit method statement of carrying out excavation work to the Engineer for approval. However, Engineer's approval shall not relieve the contractor of his responsibilities and obligations under the contract. Extra rate for each additional 0.05 m depth exceeding 1.5 m.	89	Cum	217	12781.0
3.2	Back Filling Work Back filling in foundation trenches with sand in 150mm layers including supply of filling sand (FM 0.8) and leveling, watering and compaction by frog hammer/plate vibrator to achieve minimum dry density of 90% with optimum moisture content (Modified proctor test) by ramming each layer up to finished level all complete as per instruction of Engineer-in-charge.	59	Cum	683	40297.0
	Total Cost of Earth Work				53078.0
4	PILE WORKS				

4.1	Boring/Drilling Cast-in-Situ Pile Installing bored cast-in-situ reinforced cement concrete end bearing piles using Hydraulic Rotary Rig (Concrete & reinforcement paid separately); driving temporary steel casing with necessary stiffener bands and sharp edge at bottom; casing shall be provided up to non-collapsible strata from the existing ground level (Minimum depth 6.0 Meter), boring in over-burden and through all type of strata encountered up to the founding level as described in the specification; socketing in approved strata, using bentonite slurry, including disposal of all bored materials etc. Completing as per drawings and specifications. (The boring depth shall be measured and paid from cut off level of pile only. If additional fill is placed for convenience of vehicle movement, the additional boring through this fill will not be paid extra.) Contractor shall submit the method statement of cast-in-situ pile work including sequence of boring and casting, disposal of spoils, test result of materials to the engineer for approval. However, Engineer's approval shall not relieve the Contractor of his responsibilities and obligations under contract.				
	a. 750 mm dia pile upto 27m depth	12.1*16=194	Cum	3500	679000.0

4.2	Cast-in-situ pile With reinforced cement concrete works of high slump by adding high range water reducing admixture (ASTM C494 Type A or F complying item 7.20.1 or 7.20.6)with minimum cement content 390 Kg/Cum. compressive strength f'c=25 Mpa at 28 days on standard cylinders as per standard practice of code ACI/BNBC/ASTM & cement conforming to BDS EN-197-1CEM1,52.5N (52.5 mpa)/ASTM-c 150 Type -1 best quality coarse sand(Sylhet sand or coarse sand of equivalent F.M=2.2),20 mm down well graded crushed stone chips conforming to ASTM C-33, including breaking chips, screening through proper sieves, making, placing re-bar cage in position placing and removing tri-pod as per requirement, pouring the concrete in bore-hole with the help of a trimie pipe, maintaining the trimie pipe immersed in concrete by at least 1 meter throughout the period of concreting, maintaining required slump, etc. mixing the aggregates with standard mixer machine with hoper, casting in forms, all complete including water, electricity, testing of materials and concrete etc. and other charges as per design, drawing etc. all complete approved and accepted by the engineer.(Rate is excluding the cost of reinforcement and its fabrication, binding, welding, placing and admixture (approx. doses 150 to 250 liter per bag of cement which to fix by mix design)	18.9*8 = 153	Cum	13,956	2135268.0
4.3	Formwork/shuttering, prop and necessary supports etc. (steel shuttering)	97	cum	9800	950600
4.4	Reinforcement	16*8=128*88.6 =11341/3.28 =3458*2.5 =8645	Per Kg	102.0	901790.0

4.5	Spiral	719*8 =5752*0.62 =3567	Per Kg	102.0	363834.0
4.6	Point Wilding Providing and making point welding at contact point of spiral binders at responsible intervals with the main reinforcements by electric arc welding for construction of cast in situ bored pile carefully with highly oxidized electrodes making the points prominent and accepted by the engineer.(rate is inclusive of al materials labour, tools and plants, electricity and all equipment)	5400	Point	25	135000.0
4.7	Pile Head Breaking Labor for breaking head of hardened cast in situ bored pile/pre-cast pile up to a required length by any means but without damaging the rest and removing the dismantled materials such as concrete to safe distance including scraps and cleaning concrete from steel/M.S. rods, straightening and bending of pile bars, preparation and making platform where necessary, carrying, all sorts of handling, stacking the same properly after cleaning, leveling and dressing the situ and clearing the bed etc. complete in all respects and accepted by the Engineer. (Measurement will be given for the actual pile head volume to be broken)	8	Number	5500	44000.0
	Total Cost of Pile				5209492.0
5	PILE CAP				

5.1	Reinforced cement concrete works with minimum cement content relates to mix ratio 1:1.5:3 having minimum f'cr = 30 MPa, satisfying a specified compressive strength f‟c = 25 MPa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM, Cement conforming to BDS EN-197-1-CEM-I, 52.5N (52.5 MPa) /ASTM-C 150 Type – I, best quality Sylhet sand or coarse sand of equivalent F.M. 2.2 and 20 mm down well graded stone chips conforming to ASTM C-33, making and placing shutter in position and maintaining true to plumb, making shutter water-tight properly, placing reinforcement in position; mixing with standard mixer machine with hopper, fed by standard measuring boxes or mixing in batching plant, casting in forms, compacting by vibrator machine and curing at least for 28 days, removing centering-shuttering after specified time approved; including cost of water, electricity, testing charges of materials and cylinders as required, other charges etc. all complete, approved and accepted by the Engineer-in-charge. (Rate is excluding the cost of reinforcement and its fabrication, placing, binding etc. and the cost of shuttering & centering)	75*1.56=117	Cum	13,956	1632852.0
5.2	Formwork/shuttering, prop and necessary supports etc. (steel shuttering)	75	cum	9800	735000
5.3	Reinforcement	7320/3.28 =2232*6.3 =14062	Per Kg	102.0	1434283.0
	Total Pile Cap Cost				3802135.0
6	Abutment				

6.1	Reinforced cement concrete works with minimum cement content relates to mix ratio 1:1.5:3 having minimum f'cr = 30 MPa, satisfying a specified compressive strength f‟c = 25 MPa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM, Cement conforming to BDS EN-197-1-CEM-I, 52.5N (52.5 MPa) / ASTM-C 150 Type – I, best quality Sylhet sand or coarse sand of equivalent F.M. 2.2 and 20 mm down well graded stone chips conforming to ASTM C-33, making and placing shutter in position and maintaining true to plumb, making shutter water-tight properly, placing reinforcement in position; mixing with standard mixer machine with hopper, fed by standard measuring boxes or mixing in batching plant, casting in forms, compacting by vibrator machine and curing at least for 28 days, removing centering-shuttering after specified time approved; including cost of water, electricity, testing charges of materials and cylinders as required, other charges etc. all complete, approved and accepted by the Engineer-in-charge. (Rate is excluding the cost of reinforcement and its fabrication, placing, binding etc. and the cost of shuttering & centering) Floor / roof slab, T-beam, L-beam and rectangular beam, tie beam, lintel, stair case slab and steps etc. up to ground floor.	27.5*1.56 =42.9*2=85.8	Cum	13,956	1197425.0
6.2	Formwork/shuttering, prop and necessary supports etc. (steel shuttering)	27*2=54	cum	9800	529200
6.3	Reinforcement	58*4=232*27 =6264/3.28 =1910*6.3 =12033	Per Kg	102.0	1227366
	Total Cost of Abutment				2953991.0

Total Cost of Substructure					11965618.0
7	GIRDER				
7.1	Reinforced cement concrete works with minimum cement content relates to mix ratio 1:1.5:3 having minimum f'cr = 30 MPa, satisfying a specified compressive strength f‟c = 25 MPa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM, Cement conforming to BDS EN-197-1-CEM-I, 52.5N (52.5 MPa) / ASTM-C 150 Type – I, best quality Sylhet sand or coarse sand of equivalent F.M. 2.2 and 20 mm down well graded stone chips conforming to ASTM C-33, making and placing shutter in position and maintaining true to plumb, making shutter water-tight properly, placing reinforcement in position; mixing with standard mixer machine with hopper, fed by standard measuring boxes or mixing in batching plant, casting in forms, compacting by vibrator machine and curing at least for 28 days, removing centering-shuttering after specified time approved; including cost of water, electricity, testing charges of materials and cylinders as required, other charges etc. all complete, approved and accepted by the Engineer-in-charge. (Rate is excluding the cost of reinforcement and its fabrication, placing, binding etc. and the cost of shuttering & centering) Girder, T-beam, L-beam and rectangular beam, tie beam, lintel, stair case slab.	31.25*4=125	Cum	13,956	1744500.0
7.2	Formwork/shuttering, prop and necessary supports etc. (steel shuttering)	77	cum	9800	754600.0

7.3	Reinforcement	48*90 =4320/3.28 =1317*6.3 =8298	Per Kg	102.0	846305.0
7.4	Stirrup	345*4 =1381*90 =124290/3.28 =37894*0.62 =23495	Per Kg	102.0	2396417.0
	Total Cost of Girder				5741822.0
8	DECK				

8.1	Reinforced cement concrete works with minimum cement content relates to mix ratio 1:1.5:3 having minimum f'cr = 30 MPa, satisfying a specified compressive strength f"c = 25 MPa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM, Cement conforming to BDS EN-197-1-CEM-I, 52.5N (52.5 MPa) / ASTM-C 150 Type – I, best quality Sylhet sand or coarse sand of equivalent F.M. 2.2 and 20 mm down well graded stone chips conforming to ASTM C-33, making and placing shutter in position and maintaining true to plumb, making shutter water-tight properly, placing reinforcement in position; mixing with standard mixer machine with hopper, fed by standard measuring boxes or mixing in batching plant, casting in forms, compacting by vibrator machine and curing at least for 28 days, removing centering-shuttering after specified time approved; including cost of water, electricity, testing charges of materials and cylinders as required, other charges etc. all complete, approved and accepted by the Engineer-in-charge. (Rate is excluding the cost of reinforcement and its fabrication, placing, binding etc. and the cost of shuttering & centering) Floor / roof slab, T-beam, L-beam and rectangular beam, tie beam, lintel, stair case slab and steps etc. upto ground floor	25	Cum	13,956	348900.0
8.2	Formwork/shuttering, prop and necessary supports etc. (steel shuttering)	16	cum	9800	156800.0
8.3	Reinforcement	136*90 =12240/3.28 =3732*1.6 =5971	Per Kg	102.0	609015.0
	Total Cost of Deck				1114715.0

9	TILES WORK				
9.1	Supplying, lining and fixing 304.8mm to 304.8mm thick machine made cement pavement tiles having minimum compressive strength of 27 MPa, irrespective of color &/or design. With 20 mm thick cement sand (F.M. 1.2) mortar (1 :4) base and making the Joints carefully in true straight line including cutting, laying and hire charge of machine and finishing with care etc. including water, electricity and other charges complete in all respect and accepted Engineers. (Cement CEM-II/A-M)	2271	Pieces	150	340650.0
	Total Cost Tiles Work				340650.0
10	REALING WORK				
10.1	Supplying, fitting and fixing stainless steel (SS) side railing of standard height with 2 mm thick 62 mm dia pipe for hand-rail, 15 nos horizontal pipes as per drawing, design including carrying. polishing fabricating, welding and fixing with tread by 25 mm long royal bolt etc. all respects and approved by the Engineer	3583	kg	364	1304212.0
	Total Cost of Realing Work				1304212.0
11	BRIDGE LIGHTING				

11.1	Bridge stand lights, also known as bridge lighting or bridge illumination, are used to provide visibility and enhance the safety of bridges, particularly during nighttime hours. These lights are designed to illuminate the bridge structure, including its deck, supports, and architectural elements, allowing drivers, pedestrians, and boaters to see the bridge clearly. The specific details of bridge stand lights can vary depending on the design and requirements of the bridge, as well as local regulations and standards. However, there are some general considerations and minimum requirements to ensure adequate lighting for bridge stands. Here are a few key points: Light Fixtures: High-intensity discharge (HID) lamps, such as metal halide or high-pressure sodium lamps, are commonly used for bridge lighting due to their long lifespan and high luminous efficacy. LED lighting is also becoming increasingly popular due to its energy efficiency and versatility. Luminance Levels: The required luminance levels for bridge stand	20	Numb er	10000	200000.0
	Total Cost Lighting				200000.0
Total Cost of Super Structure					9301399.0
12	RATES OF MAN, MATERIAL AND MARK-UPS				
12.1	5-ton capacity truck-fare in Dhaka city including loading & unloading	30 trip	Per Trip	3000	105000.0
	GRAND TOTAL				21985195

3.3 PROJECT SCHEDULE

Construction Schedule															
RCC Pedestrian Bridge Project		Starting Date: 01/6/2023				Hand-over Date: 03/06/24				Period of Construction: 20 Mon.					
ID	Work Name	Length (days)	Jun.-23	July.-23	Aug.-23	Sep-23	Oct.-23	Nov.-23	Dec.-23	Jan-24	Feb.-24	Mar-24	Apr.-24	May.-24	Jun.-24
1.	Site preparation and mobilization	60													
	Excavation	30													
2.	Piling works	60													
3.	Casting of Pile Cap	30													
4.	Pile Head Breaking	15													
5.	Earth Filling	15													
6.	Abutment Work	30													

7.	Girder Casting	50													
8.	Slab Work	30													
9.	Tiles Work	20													
10	Approach Railing	30													
11	Side Railing	5													
12	Light Post Setup	10													
13	Drainage Pipe Setup	5													

3.4 ETHICAL ISSUES:

In our project:
Pedestrian bridge has never been built over Rampura canal, consequently no previous data or calculation was done. So we analyzed it in a completely new way. Provide all data and calculation to us. Only ETAB and AutoCad paid versions are not available so I have to use the Crack version. Which is beyond engineering ethics.

In construction Field:
The construction field is susceptible to various ethical issues that can arise throughout the project lifecycle. Identifying and addressing these ethical concerns is essential to promote responsible and ethical practices. Here are some common ethical issues in the construction field and suggestions for mitigating or removing them:

1. Corruption and Bribery: Corruption and bribery can occur in construction projects, leading to unfair advantages, compromised quality, and inflated costs. To remove these ethical issues, it is crucial to establish a culture of transparency and accountability. Implement clear policies that prohibit bribery and corruption, conduct thorough due diligence when selecting contractors and suppliers, and promote a whistleblowing mechanism to report any unethical activities.

2. Conflict of Interest: Conflict of interest can arise when individuals involved in the construction project have personal or financial interests that could compromise their objectivity or decision-making. To address this, establish robust conflict of interest policies that require stakeholders to disclose any potential conflicts and recuse themselves from decision-making processes when conflicts arise. Transparency and open communication are key to preventing and managing conflicts of interest.
3. Health and Safety Violations: Neglecting health and safety standards in the construction field can lead to accidents, injuries, and even fatalities. To remove this ethical issue, prioritize the health and safety of workers and the public. Establish and enforce comprehensive health and safety policies, provide proper training, conduct regular inspections, and ensure compliance with applicable regulations. Foster a culture of safety and empower workers to report safety concerns without fear of reprisal.
4. Environmental Impact: Construction projects can have significant environmental impacts, including habitat destruction, pollution, and resource depletion. To address this ethical issue, incorporate sustainable practices into the project. Conduct environmental impact assessments, adhere to environmental regulations, promote resource conservation, adopt green building techniques, and explore the use of renewable materials. Engage stakeholders in sustainable decision-making processes and consider the long-term environmental consequences of construction activities.

5. Fair Labor Practices: Ethical concerns can arise when construction workers are subjected to unfair labor practices, such as low wages, long working hours, and poor working conditions. To remove this issue, ensure fair labor practices throughout the project. Adhere to labor laws and regulations, provide fair wages and benefits, promote a safe and healthy work environment, and support workers' rights to organize and bargain collectively. Regularly monitor and audit labor practices to identify and rectify any violations.

6. Quality Assurance: Ethical concerns can arise when construction projects compromise quality to cut costs or meet deadlines. To address this issue, prioritize quality assurance throughout the project. Develop and implement robust quality control procedures, adhere to industry standards and specifications, conduct regular inspections and testing, and engage qualified professionals for design and construction activities. Emphasize the importance of delivering high-quality outcomes that meet or exceed client expectations.

By addressing these ethical issues proactively, construction projects can promote responsible and sustainable practices, enhance stakeholder trust, and contribute positively to society. It is essential to establish clear policies, provide adequate resources for compliance, conduct regular monitoring and auditing, and hold individuals accountable for their actions. Ultimately, promoting an ethical culture in the construction field requires a collective commitment from all stakeholders involved.

Chapter 4
Conclusion

Conclusion:

In conclusion, our project objective revolves around the successful execution of a bridge construction project. This involves carefully selecting a suitable bridge type and site, followed by undertaking a preliminary structural design that considers factors such as integrity, aesthetics, and functionality. By finalizing the structural design based on safety and performance criteria, we ensure a robust and reliable bridge. Drafting the structural design enables us to effectively communicate our plans. Preparing the Bill of Quantity (BOQ) based on materials, quantities, and estimated costs allows for accurate budgeting and resource allocation. Lastly, developing a project schedule outlines the sequential steps and timelines, ensuring a well-organized and timely completion of the bridge construction process. Through diligent attention to these objectives, we aim to deliver a successful and efficient bridge project.

A complex engineering problem refers to a challenging issue that requires advanced engineering knowledge and expertise to address. It involves a combination of intricate factors and considerations that demand careful analysis, innovative solutions, and effective project management. Here are some key attributes of complex engineering problems and provide our project achievement below:

Complex Engineering Problems	Our Achievement
Cannot be resolved without in-depth engineering	Before starting our project, we have read books of various authors besides having enough knowledge from AASHTO code and BNBC, we have done in depth calculation. Project costing is done as per chart of PWD.
Involves wide-ranging or conflicting technical, engineering and other issues	While analyzing our RCC Pedestrian Bridge, we came across many wide range technical problems. We had no opportunity to provide any support between the bridges, due to which it was challenging for us to analyze the 90ft bridge without extra support. But we solved the problem with our engineering knowledge.
There is no obvious solution, and abstract thinking and originality in analysis are required to formulate suitable models	Pedestrian bridge has never been built over Rampura canal, consequently no previous data or calculation was done. So we analyzed it in a completely new way.
Involves infrequently encountered issues	We had many minor problems in this project. The span length of the bridge will depend on the site conditions and required clearance. Due to the long span of our bridge, I have added some value outside the code. Besides, the price of all units was not given in the field of BOQ in PWD. That we have to assume
Are outside problems encompassed by standards and codes of practice for professional engineering	In the design of the concrete pedestrian bridge, we have followed industry best practices and adhered to relevant codes and standards to ensure a safe and structurally sound structure. The design has primarily been based on [mention the primary code or standard used], which provides comprehensive guidelines for the design, construction, and maintenance of long-span pedestrian bridges. We calculated the railing load which was not mentioned in the code.

Involves diverse groups of stakeholders with widely varying needs	In this project we have made a survey. We did the survey. We have done common problem analysis of common people. And the project requirement where distributed from the advisor as a role of Eastern Housing authority.
High level problems including many component parts or sub-problems	High-level problems often consist of multiple component parts or sub-problems that need to be addressed in order to achieve a comprehensive solution. We found many sub-problems during project analysis. We first analyzed the problem, then identified the sub-problem, and finally designed the solution.

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Appendix A
Drawing Detail

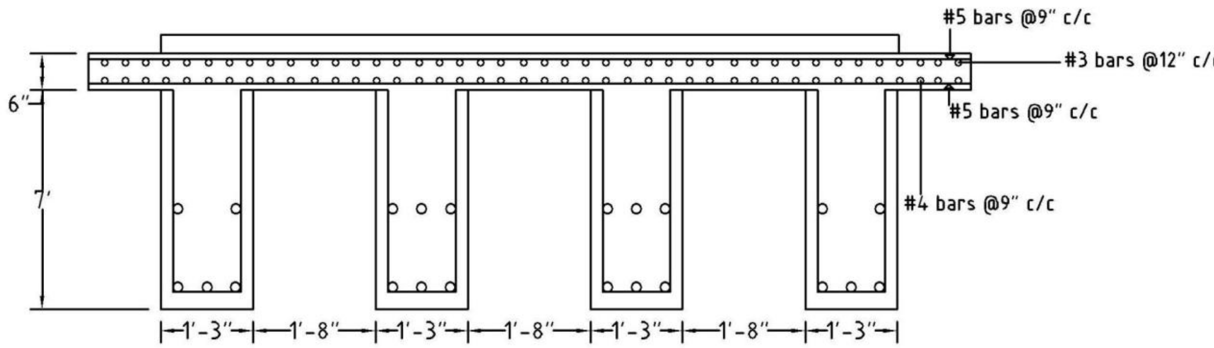


Figure 1 : Girder and Slab Reinforcement Detailing

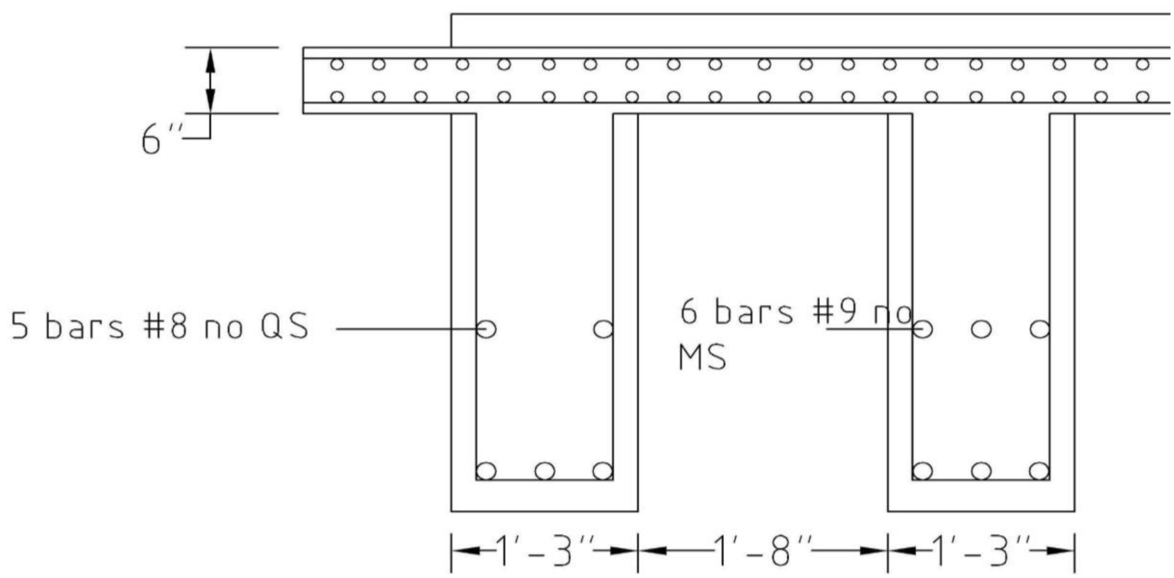
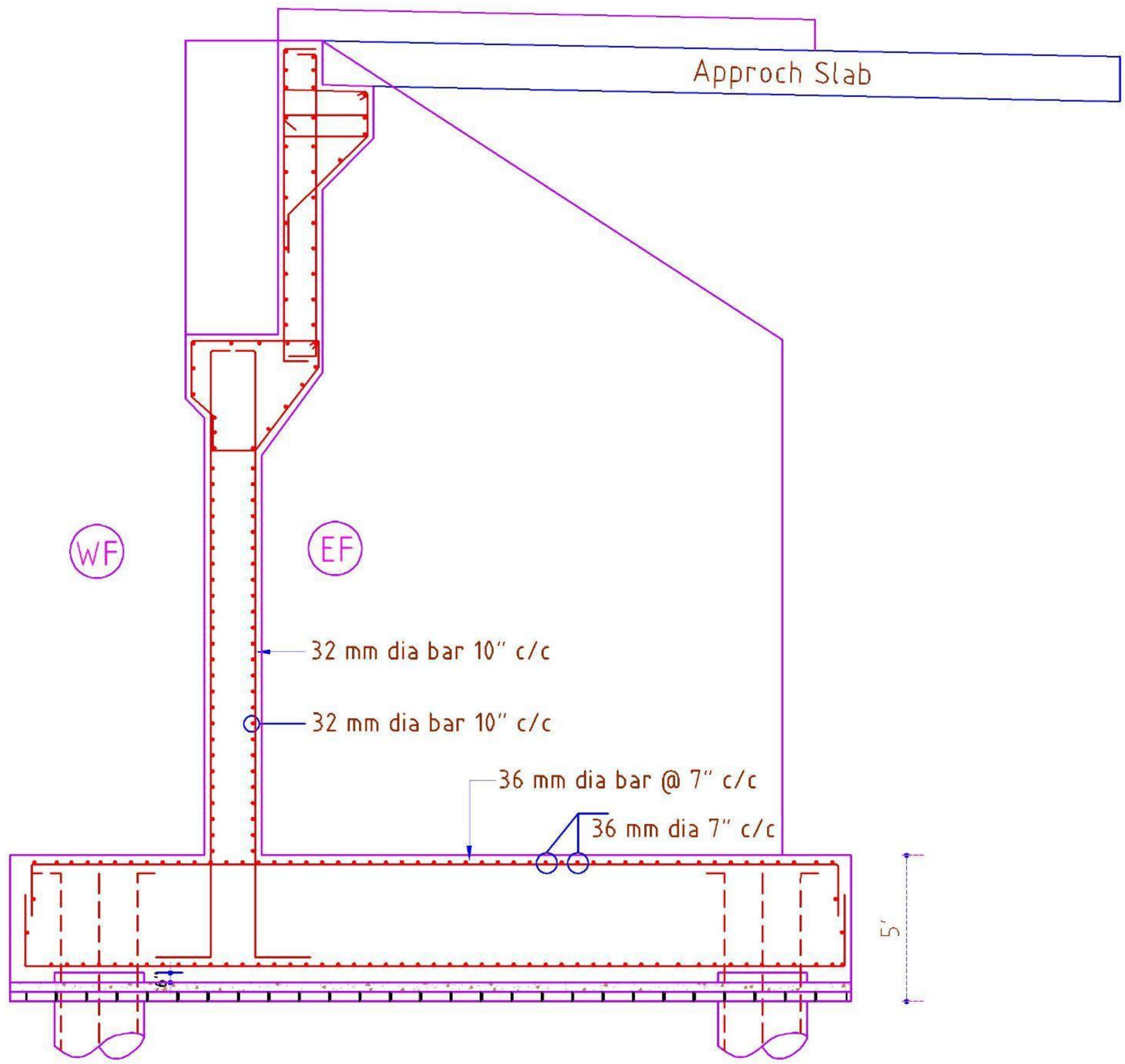


Figure 2 : Quarter span and Mid Span Girder Reinforcement Detailing



REINF. SECTION OF ABUTMENT AND PILE CAP (SECTION 1-1)

Figure 3 : Reinforcement of Abutment and Pile Cap

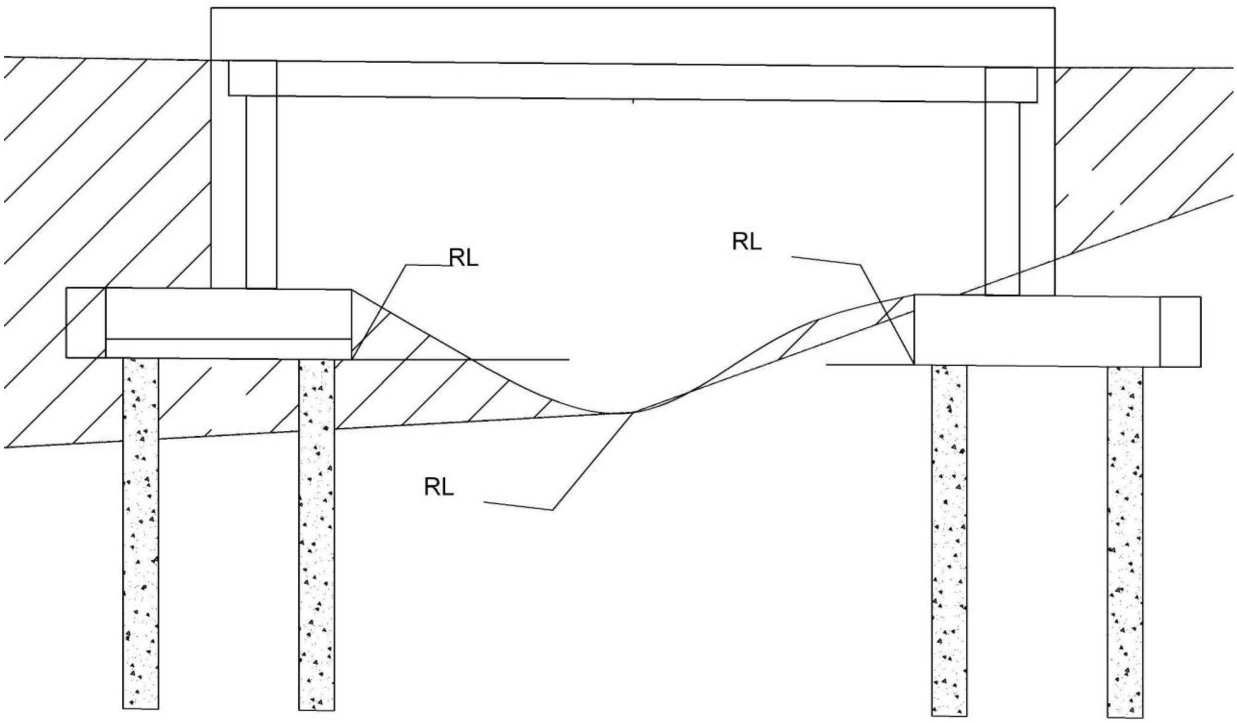


Figure 4 : Pile Distribution

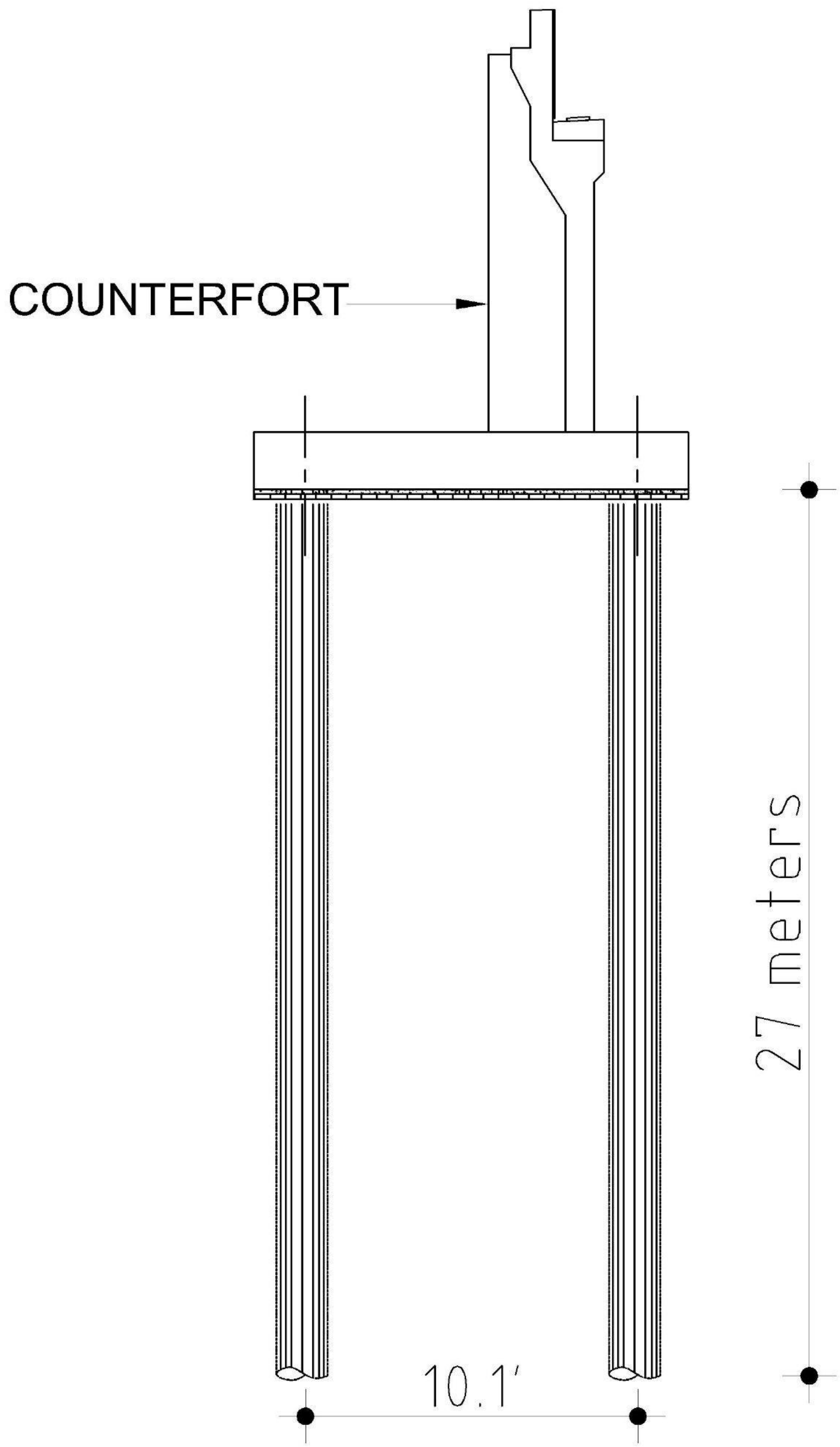


Figure 5 : Abutment pile depth and c/c distance.

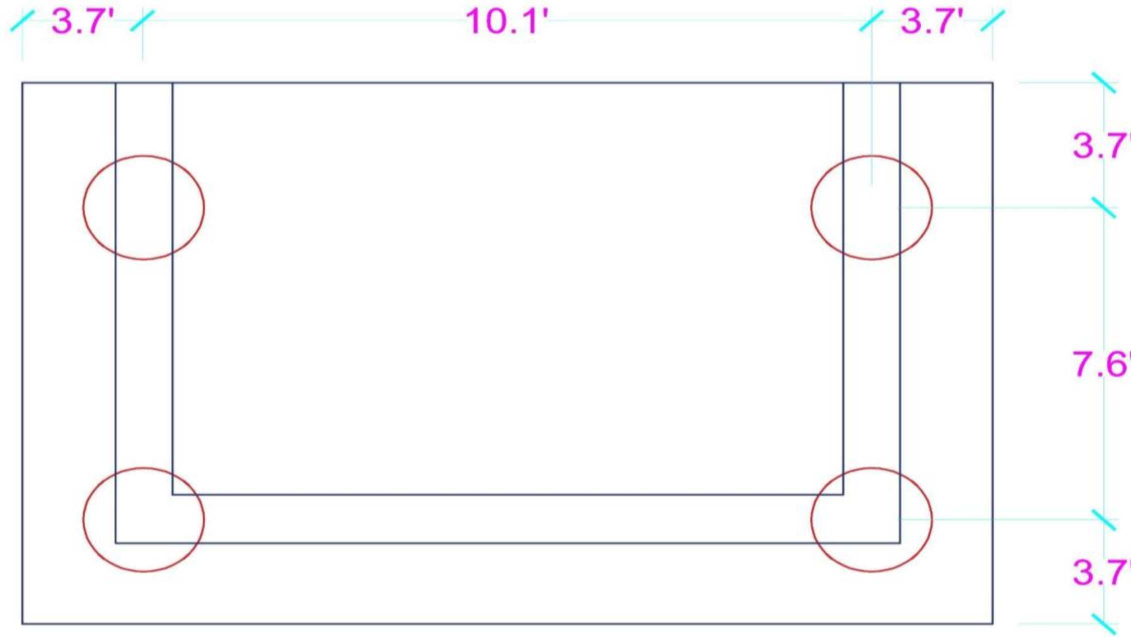


Figure 6 : Pile cap spacing

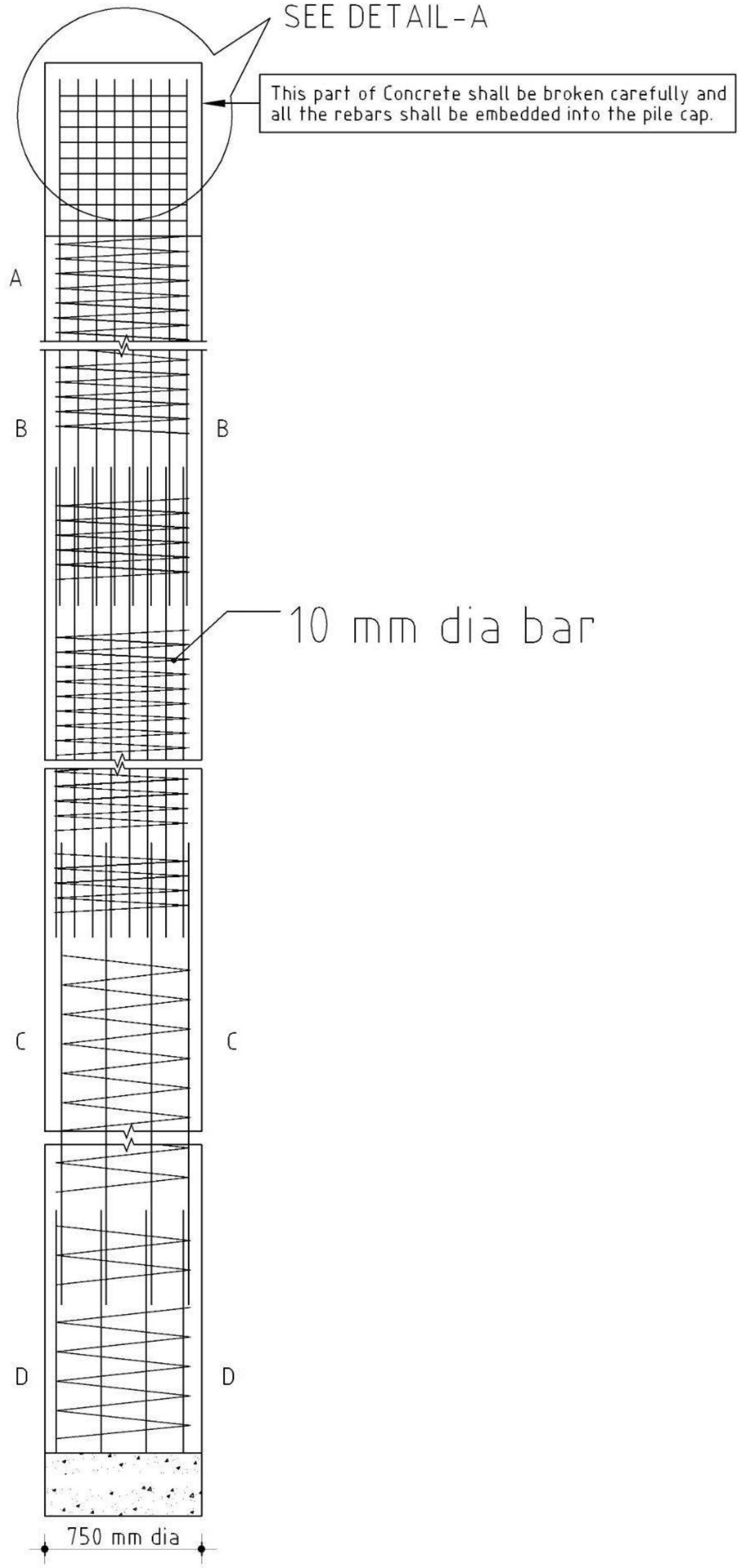

SEE DETAIL-A
This part of Concrete shall be broken carefully and all the rebars shall be embedded into the pile cap.
A
B
B
10 mm dia bar
C
C
D
D
750 mm dia

Figure 6 : Abutment Pile Cap Reinforcement Detailing

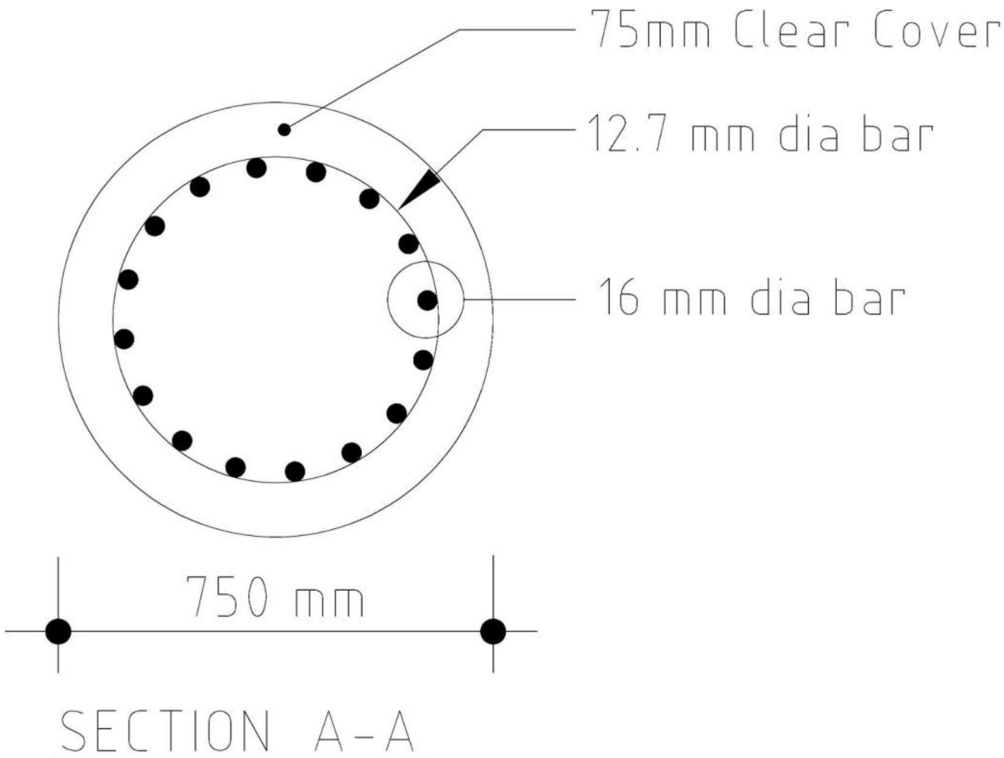


Figure : Cross-Section of the pile.

Appendix B

Code of Ethics of IEB

The Code of Ethics of IEB is mentioned below.

THE INSTITUTION OF ENGINEERS, BANGLADESH (IEB)

CODE OF ETHICS

(Approved in the 476th Central Council Meeting, IEB, held on 6.8.2003)

1. I solemnly promise that as a member of The Institution of Engineers, Bangladesh I shall uphold and advance the integrity, honor and dignity of the engineering profession using my knowledge and skill and shall hold paramount the safety, health and welfare of the public and shall try to comply with the principles of sustainable development in the performance of my professional duties.
2. I shall be honest and impartial and serve with complete fidelity the public, employer and clients. I shall not accept remuneration for services rendered other than that form my employer or with my employer's permission.
3. I shall perform services only in areas of my competence.
4. I shall build my professional reputation on the merit of my services and shall not complete unfairly with others.
5. I shall act in professional matters for my employer or client as faithful agent or trustee and shall avoid conflict of interest and avoid deceptive acts.
6. I shall issue public statements only in an objective and truthful manner, and shall not in a self-laudatory language or in any manner derogatory to the dignity of the profession or professional bodies, neither advise or write articles for publication, nor shall authorize such advertisements to be written or published by any other person.
7. I, without disclosing the fact to my employer in writing shall not be director of or have a substantial financial interest in, nor be an agent for any company, firm or person carrying on any contracting consulting or manufacturing business which is or may be involved in the work to which my employment relates, nor shall I receive directly or indirectly any royalty, gratuity or commission or any article or process used in or for the purpose of the work in respect of which I am employed unless or until such royalty, gratuity or commission has been authorized in writing by the employer.
8. I shall support the professional and technical societies of my discipline.
9. I, in connection with work in country other than my own shall order my conduct according to these rules, as far as they are applicable; but where the country has recognized shandards of professional conduct, I shall adhere to them.
10. I shall not offer, guide, solicit or receive, either directly or indirectly any political contribution in an amount intended to influence the award of a contract by the public authority.
11. I solemnly promise I shall avoid bribery and extortion in any form. If I encounter such acts done by any member. I shall be ethically bound to report it to the Ethical Review Board (ERB) of IEB. (ERB is to be formed)
12. I shall continue my professional development throughout my career, and shall provide opportunities and support for the professional development of the engineers under my supervision
13. A member who shall be convicted by a competent tribunal of criminal offence, which in the opinion of the disciplinary body renders him unfit to be a member, shall be deemed to have been guilty of improper conduct.