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Study of the Under Pass Structure in Gatot Subroto – Cokroaminoto Intersection-Roads, Denpasar – Bali

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Abstract

Denpasar represents a town with the amount of most residents in Bali and has a tendency will increase. This of course will be followed by accelerating the development of various sectors. This condition will be creating various urban problems, among the other problem is the jam of traffic, which is caused by the existence of unbalanced growth of very fast vehicles (14%) compared to with accretion of new streets which only reaching 3,6% a year. To overcome the problem one of the efforts able to be conducted is by improving the quality of street service which have there, especially at critical joint streets and intersection streets, like Gatot Subroto - Cokroaminoto intersection roads. However progressively is fast accretion amount of vehicle, this method will not give optimal service, so that requires another way of problem-solving. Another Arrangement Alternative to solve this jam is with an intersection street is not at a piece of, such as which have been applied at Simpang Dewa Ruci. In general, the type of construction is fly over and underpass, but under experience at Simpang Dewa Ruci, from the social and cultural aspects happened deduction of fly over type. So that the study is limited to underpass type. According to the result of soil investigation at that location, the election of cheap type is boring pile construction with 60 cm diameter, reinforcement 14D22, U-40 steel and K-350 concrete, strung up with secant pile (bore pile without reinforcement and strength of concrete K-175). While the beam of the bridge is from reinforced concrete plate K-350 strength, 40 cm thick, reinforcement equal to 21,92 cm2, attached reinforcement by D22-15 (interesting side) and D22-30 (stressing side).

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1 Introduction

Denpasar is the capital city of Bali Province, which since January 15, 1992, has been designated as Denpasar City with various potentials, especially in the field of tourism and creative industries. Therefore, the population tends to continue to increase and is accompanied by an increase in the pace of development in various sectors which ultimately causes various urban problems, including traffic congestion problems.

Traffic congestion is caused by an imbalance between the very rapid growth of vehicles and the addition of new roads (Ministry of Public Works, 1997). Currently, vehicle growth per year has reached 14% while the length of the road is only 3.6% per year (Regional Regulation No. 16 of 2009 concerning the Spatial Plan for the Province of Bali). On the other hand, limited land makes it impossible to add new roads easily. Therefore, one of the efforts that can be done is to improve the quality of existing road services, especially on critical road sections and intersection points such as the Gatot Subroto - Cokroaminoto intersection - roads.

To overcome this, the Denpasar City Transportation Service has planned to build a traffic control device through the 2013 budget allocation at four intersections, including at the intersection of Jalan Gatot Subroto - Cokroaminoto and Jalan Maruti - Cokroaminoto. However, considering that the delays at the two intersections are relatively high, especially at the Gatot Subroto - Cokroaminoto intersection, a study is needed to determine the best, effective and efficient alternative treatment for the long term both technically and economically without ignoring environmental and socio-cultural aspects (Chen et al., 2009; Jin et al., 2020).

The Gatot Subroto - Cokroaminoto intersection is a four-arm intersection regulated by APILL 4 (four) phases. Long queues, especially during peak hours. The intersection arrangement with APILL seems to no longer be able to serve the high volume of traffic which is increasing every year. It is estimated that there will be very severe traffic jams in the next few years. When the intersection arrangement with APILL is no longer able to provide optimal service, another alternative arrangement is with a non-level intersection (Kister et al., 2007; Lam et al., 2015).

A non-level intersection is an intersection where two or more road segments meet each other not in one plane but one segment is above or below another road segment (Aditya Raharjo, 2012). In general, the type of non-level crossing construction that can be built is a fly-over or underpass (Aditya Raharjo, 2012). However, based on experience in the planning of the Dewa Ruci intersection, from the socio-cultural aspect, there was a rejection of the flyover type. So the study is limited to the Underpass type.

2 Materials and Methods

An underpass is a transverse road under another road or a non-level crossing by making a tunnel under the ground, (Aditya Raharjo, 2012). The main structure of the underpass includes two important parts, namely the open wall which functions as a retaining wall/sheet pile (cantilever plaster wall), and the closed wall which is planned to be an integral part of the bridge floor slab.

Structural studies on these two things are based on primary data obtained from survey results in the field, both in the form of soil testing data and traffic data. In the planning of the Gatot Subroto (Gatsu) Underpass, the retaining wall is planned to use a reinforced concrete type bore pile concrete pile combined with a secant pile (bore pile without reinforcement with a non-structural quality concrete mix that functions as a filler between the bore pile structure).

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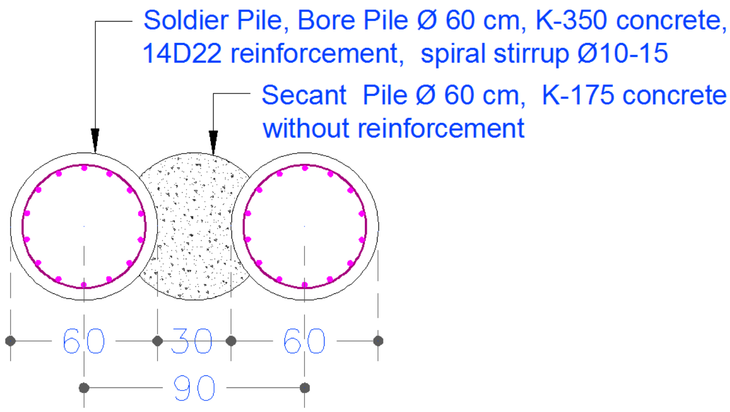

Figure 1. Type of bore pile retaining wall

The selection of this system is carried out with the consideration that in its implementation it will be easier to work because it does not require the installation of formwork and further soil excavation can be carried out after the bore pile concrete is of sufficient age. Pile loading due to soil pressure is calculated based on the value of soil properties obtained from the results of soil investigations (Shavadze et al., 2022).

Broadly speaking, the bridge construction consists of two main components, namely the superstructure (upper structure) and the substructure (substructure) (Ministry of Public Works, 1987). The superstructure is the part of the bridge that receives the direct load from the people and vehicles that pass through it. The superstructure consists of the main components, namely the bridge floor, main frame, girders, diaphragms and supports. In addition, there are also supporting components, namely sidewalks, rallying, drainage, lighting and parapets. The substructure is the part of the bridge that receives the load from the superstructure plus the soil pressure and impact forces from the crossing under the bridge. The substructure includes the pier, the abutment and the foundation (Pacheco-Torgal & Jalali, 2011; Ortiz et al., 2009; Lim et al., 2012).

In the preparation of the Feasibility Study (FS.) The underpass Gatsu bridge is designed using a plate system (without the use of girders), this was chosen because the length of the bridge is not too large. In the absence of beams, the net height requirement of the bridge under the bridge can be minimized so that it will reduce the volume of excavation. The bridge plate is then designed to be integrated with the pillars of the retaining sheet pile so that in this position the sheet pile will receive the load from the side soil pressure and will also receive and transmit the load from the bridge slab plate (Brehme et al., 2021; Jiang et al., 2022; Wysocki et al., 2022). Calculation of internal forces until the reinforcement design is obtained for both the sheet pile construction and the superstructure and substructure of the bridge will be carried out using SAP 2000 v.14 software.

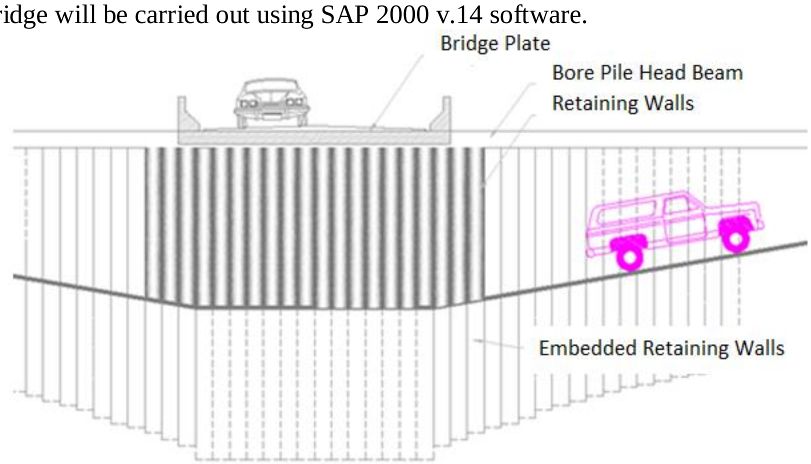

Figure 2. Construction of bridge slabs and retaining walls

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3 Results and Discussions

3.1 Determine the drill pile anchorage length (h')

The forces on the bore pile walls are caused by soil pressure and pressure due to uniform loads on the soil surface [4]. While the influence of groundwater pressure is ignored because based on ground investigations the water table is in a position far below the ground surface (± 10m).
Ground pressure coefficient:

Soil shear angle Ø = 30º [7]
ka = tg^2 (45 - Ø /2) = 0.33
kp = tg^2 (45 +Ø /2) = 3.00

Loads:
Uniform load on the vehicle floor q = 1617 kg/m'
The load due to the weight of the soil volume t = 1693 kg/m3

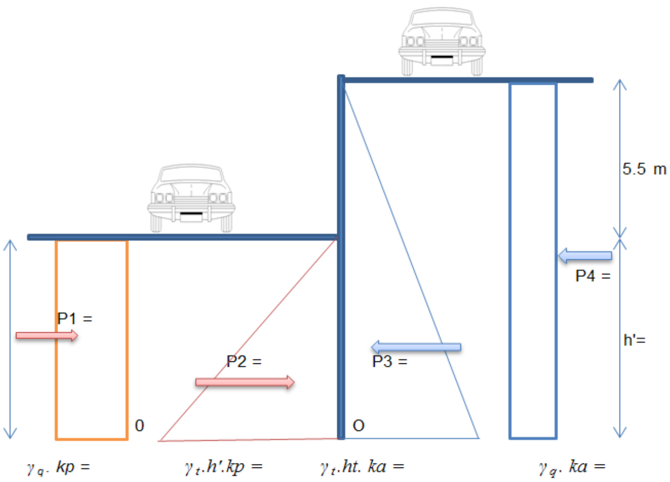

Figure 3. Soil pressure on pile walls for calculation of bore pile length

Assuming the drill pile depth up to point O is h'. With several trials used h' = 4.3595 m,
Forces acting on a wall 1 m wide: (Ali Zakariya, 2012)
P1 = q. kp . h' = 21.15 tons
P2 =1/2. t. kp . h' 2 = 48.26 tons
P3 = 1/2 . t. you . (5.5 + h')2 = 27.40 tons
P4 = q. you . (5.5 + h') = 5.31 tons

Equilibrium moments about point O:
Σ Mo = 0
P1 * h'/2 + P2 * h'/3 - P3 * (5.5 + h')/3 - P4 * (5.5 + h')/2 = 0
46.10 + 70.14 - (90.06) - (26.17) = 0.004 ~ 0 (OK)

So the depth of the bore pile from the base elevation of the underpass is 435.95 cm, but to further ensure that the bore pile which is used as a wall has a completely wedged behaviour on the ground, the driving depth is taken to be 2 times the part of the bore pile that is not driven (Aditya Raharjo, 2012). So the total length of the bore pile = 3 x 5.5 m = 16.5 m

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3.2 Design of retaining wall reinforcement (bore pile)

The bore pile size used is Ø60 cm, with 2 types:

1) Bore pile with reinforcement, compressive strength concrete K-350 kg/cm^2
2) Bore pile without reinforcement (secant pile), compressive strength concrete K-175 kg/cm^2

Reinforcement design is based on the retaining wall section with a maximum elevation (5.50m depth), assuming that the bore pile is in a pinched state. The load that is calculated to work is the result of active earth pressure and the uniform load due to the vehicle floor. For reinforcement, a 1 pc bore pile is taken with a horizontal load of 90 cm wide.

Forces acting:
$P1 = 1/2 . \gamma_t.ka. 0,9. 5.5^2 = 7674.31$ kg
$P2 = \gamma_q. ka . 5.5 .0,9 \quad = 2665.39$ kg

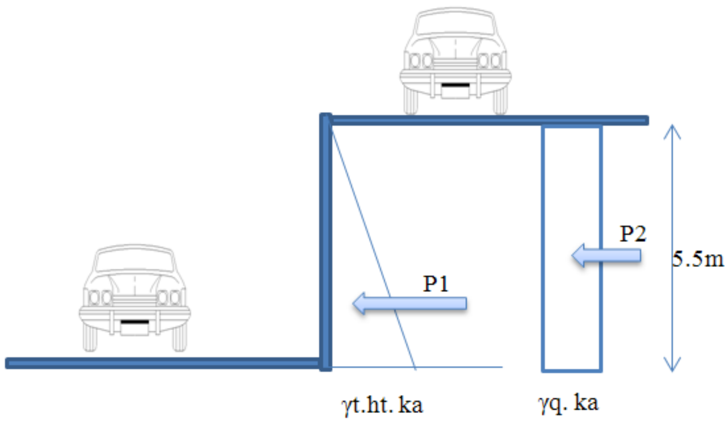


Figure 4. Soil Pressure on Pile Walls for Bore Pile Reinforcement.

Moments that occur in the wedged bore pile:
M = P1 x 5.5/3 + P2 x 5.5/2
= 21399.38 kg.m

From the calculation of reinforcement using SAP. 2000 v14 requires the installation of reinforcement with an area of 46,471 cm2, (number of reinforcements in 1 bore pile = 14D22).

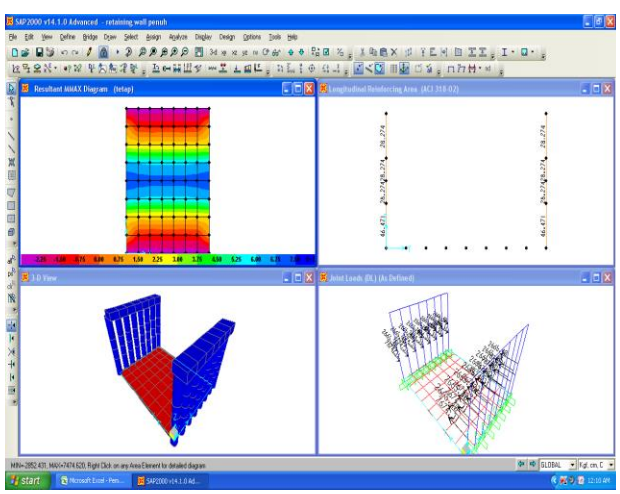


Figure 5. Data Analysis SAP 2000 for Bore Pile Reinforcement

3.3 Bridge Structure Planning (Floor and wall slabs)

Assumptions are taken in bridge design:

1) Bridge span = 8.5m
2) The bridge floor plate is made of reinforced concrete with a thickness of 40 cm, K-350 concrete, and U-39 steel.
3) The bridge slab is analyzed as a flat beam concrete measuring 90/40 cm. The ends of the bridge floor plates are joined to the bore pile columns of the retaining wall.

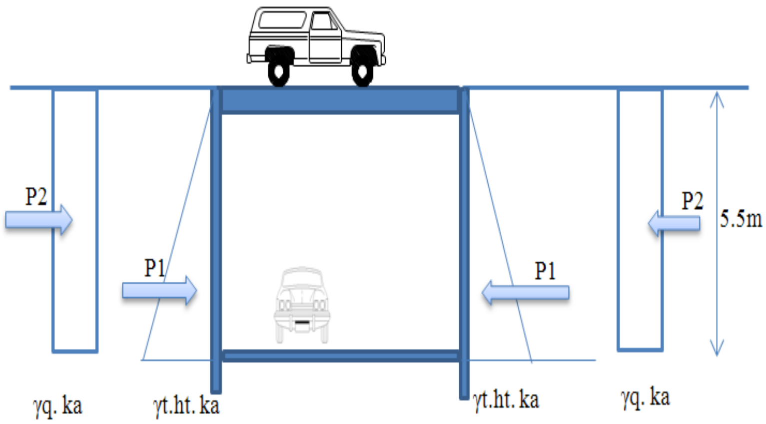
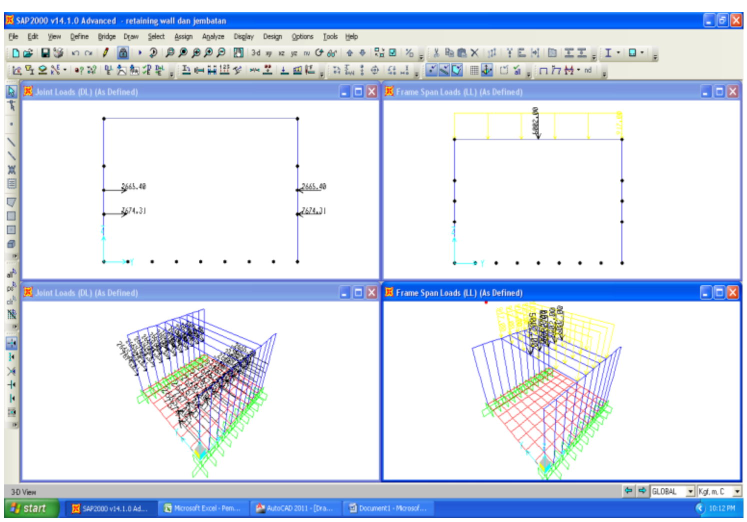


Figure 6. Loading of the Bridge Structure.

Forces acting on the abutment walls:
P1 = 1/2 . γ_t.ka. 0,9. 5.5^2 = 7674.31 kg
P2 = γ_q. ka . 5.5 .0,9 = 2665.39 kg

The loading on the bridge plate is the result of:
own weight of 40 cm thick concrete slab
asphalt cover weight t = 5 cm
D Load divided : 917 kg/m'
D line load : 5002 kg



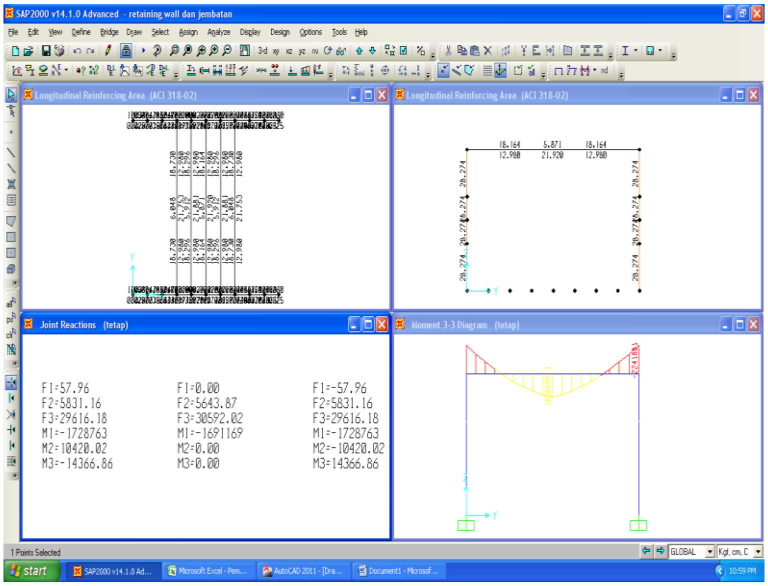


Figure 7. Forces in Bridge Structure

The results of the study of the Gatsu underpass structure are presented in Figure 9 as follows:

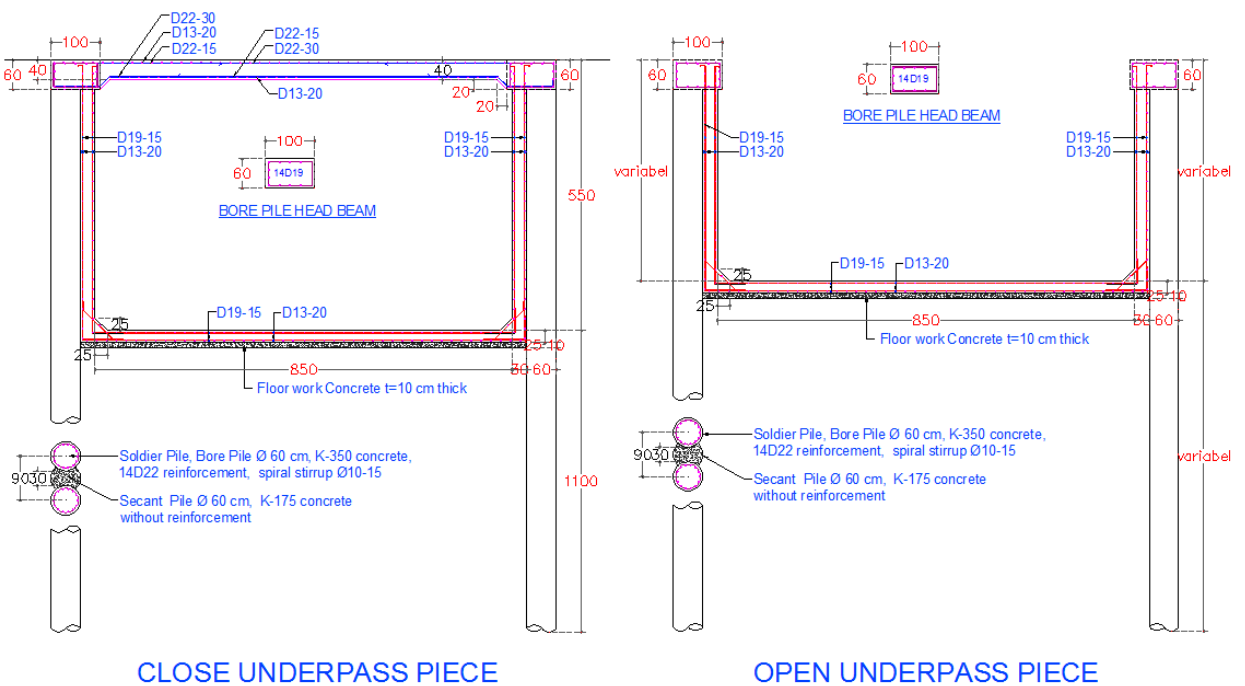


Figure 8. Gatsu - Cokroaminoto Underpass Structure

4 Conclusion

From the results of the SAP calculation, it was found that the maximum area of beam reinforcement - bridge plate is 21.92 cm^2, D22-15 (tensile side) and D22-30 (tensile side) reinforcement are installed on the abutment wall (bore pile) as a support for the bridge plate beam. requires a smaller reinforcement area than the bore pile in the open area (outside the bridge) so that the reinforcement is the same as the open bore pile. (14D22). The maximum axial force that occurs on the bore pile is 30.6 tons, while according to the results of soil investigations and referring to the equations for calculating the pile bearing capacity (Bowles, 1993), the bearing capacity of a single drill pile foundation is obtained at a depth of 5 meters, with diameters between 0.3 – 0.6 meters ranging from 83.2 tons to 172.5 tons (Soilindo, 2013). This means that the use of bored piles with a diameter of 60 cm and driven to a depth of 16.5 m from the ground (11 m from the underpass) has guaranteed safe construction.

Conflict of interest statement
The authors declared that they have no competing interests.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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