www.bircu-journal.com/index.php/birci
Budapest International Research and Critics Institute-Journal (BIRCI-Journal)
Humanities and Social Sciences
ISSN 2615-3076 Online)
ISSN 2615-1715 (Print)
Budapest Institute

Box Traffic/Underpass Structure Calculation Analysis
(Case Study of Box Traffic/Underpass on Kuala Tanjung – Indrapura Toll Road Section II Zone 2)

Alexander Tuahta Sihombing[1], Irwan Hura[2]
[1,2]Universitas Asahan, Indonesia
alexandertuahtasihombing@gmail.com, Irwanhura96@gmail.com

Abstract

The purpose of this study was to determine the feasibility of planning box traffic/underpass on the Kuala Tanjung-Indrapura toll road. So that later the results of the planning can be used as a reference for planning similar structures. The author's objectives from the implementation of this final project are: 1) Knowing the magnitude of the load value that occurs in the box traffic/underpass building structure. 2) Knowing the feasibility of the strength of the planned traffic/underpass structure. 3) Analyze the structure of the box traffic/underpass that has been planned. After analyzing and designing using the SAP 2000 Program on the BOX TRAFFIC/UNDERPAS Building on the Kuala Tanjung – Indrapura Toll Road Section II Zone 2 which is adjusted to the Procedure for Calculation of the Bridge Loading Regulations according to SNI 1725-2016 and RSNI T-02-2005, based on structural analysis which is reviewed, it can be concluded that in the planning of box traffic/underpass, it is in accordance with the standard of bridge loading planning.

Keywords
box traffic/underpass; economic; structure calculation

I. Introduction

The need for transportation routes is currently very large due to the number of vehicles that increase every year. This problem is of course a special concern for the government to build adequate transportation routes. One of them is by creating barrier-free transportation routes or better known as toll roads.

The Sumatra Cross Line, which is a very important route as a connecting route between the cities of Medan, Tebing Tinggi, Batubara Regency, Asahan Regency and Tanjung Balai City every year is used as a homecoming route. The high traffic flow and the absence of other alternative routes cause congestion on this road to be unavoidable. Therefore, traffic engineering is needed to break down congestion. However, the increasing economic movement in the North Sumatra area causes the volume of vehicles to increase every year, while the limited land to widen roads is one of the obstacles.

The economic condition of the population is a condition that describes human life that has economic score (Shah et al, 2020). Economic growth is still an important goal in a country's economy, especially for developing countries like Indonesia (Magdalena and Suhatman, 2020).

One alternative that can be done by looking at the current condition is to build a toll road. When toll road construction is carried out, of course the land or area crossed by the toll road will be closed, resulting in the area being divided and unable to connect with one another. No exception, connecting roads between villages or villages are blocked because of the toll road that passes through the village area.

Budapest International Research and Critics Institute-Journal (BIRCI-Journal)
Volume 4, No 4, November 2021, Page: 10676-10697
e-ISSN: 2615-3076 (Online), p-ISSN: 2615-1715 (Print)
www.bircu-journal.com/index.php/birci
email: birci.journal@gmail.com

An underpass is a passage under something, especially a part of the road or railroads or pedestrian paths. Some civil engineers define an underpass as a passage below the surface that is less than 0.1 miles or 1,60934 km long. Usually used for vehicular traffic (generally cars or trains) as well as pedestrians or cyclists.

To prevent unwanted risks, it is necessary to calculate the loading of the structure. The load calculation itself consists of manual calculations and calculations using a structural load calculator application.

The suitability of construction materials used when constructing structures is highly dependent on the results of the calculation of structural loading. So that this loading analysis is very necessary in every building construction to prevent the risk of accidents caused by the structure going forward.

Based on the description above, the author in order to complete the Final Project of the Undergraduate Study Program (S1) at the Department of Civil Engineering, Asahan University (UNA) will analyze the load calculation on the box traffic structure on the Kuala Tanjung-Indrapura toll road section II zone 2. Then The author gives the title of this Final Project with the name "ANALYSIS OF TRAFFIC/UNDERPAS BOX STRUCTURE CALCULATIONS (Case Study of Traffic Boxes/Underpasses on Kuala Tanjung - Indrapura Toll Road Section II Zone 2)".

II. Review of Literature

2.1 Box Traffic/Underpass

Box traffic/Underpass is a transverse road under another road or a non-level crossing by making a tunnel under the ground. Proper construction is required in the implementation of box traffic/underpass roads. Box traffic construction is an excavation with the construction of a retaining structure in a vertical position (Sugihart, 2009).

Box traffic/underpass is a tunnel panel with a certain size as a place for vehicles to pass through the underpass. This underpass box must be waterproof and soundproof. Watertight so that water from above does not seep into the box. Soundproof so that the noise from the traffic above is not heard into the box (sigit dwi prasetyo, 2014).

The difference between box traffic/underpass and tunnels is that a tunnel is a type of road that is made in such a way that the road usually penetrates a hill or between two adjacent valleys, for example the tunnel in the Nagreg area, West Java.

The Traffic Box/underpass is built to break down congestion or as a transportation link so that the traffic flow above the traffic box is not disturbed.

The underpass serves as a pathway for local residents to pass by as well as connecting the distribution route for the needs of the local community. Underpass is one solution to overcome congestion at intersections. An underpass is a passage below ground level, especially part of a road, rail or pedestrian path. (Mila Roofi Priliyani, 2017)

Usually underpass buildings can be found along toll roads, or sometimes can also be seen at several intersections in big cities that often experience congestion. Usually in big cities or certain areas, the underpass walls are decorated with regional ornaments, such as the example of the underpass at the Brigjen Katamso intersection, Medan.

2.2 Loading

A building structure, be it tall buildings, bridges, or even underpasses must be planned to be able to bear the loads acting on the structure, including gravity loads and lateral loads. Gravity loads acting on the structure include dead loads and live loads. Dead load acting on the structure is caused by the weight of the structure itself and additional weight such as the weight of the soil above the underpass. Meanwhile, which includes lateral loads are soil loads and earthquake loads.

There are different types of loads that can act on the design of a structure, the nature and characteristics of these loads vary according to the design, use, location, and type of material used. Design requirements are generally determined based on the strength of a structural design to withstand the maximum load acting on the structure.

Loads are generally classified into three types, namely live loads, dead loads and environmental loads (Dipohusodo, 1999).

In calculating the magnitude of the load acting on the structure, we can refer to the standards set in Indonesia, the Indonesian Loading Regulations for Buildings 1983 (PPIUG 1983). And for now the calculation for the load that works on the Box traffic/underpass structure is regulated in the bridge loading regulations according to SNI 1725-2016 and RSNI T-02-2005.

Following are the load combinations that must be reviewed according to SNI 1725 2016:

1. Strength1: a combination of loading that takes into account the forces that arise on the bridge under normal conditions without taking into account the wind load. In this combination all the nominal forces that occur are multiplied by the appropriate load factor.
2. Strength II: combination of loadings related to the use of bridges to carry special vehicle loads determined by the owner without taking into account wind loads.
3. Strong III: the combination of loading with the bridge is subjected to wind loads of 90 km/hour to 126km/hour.
4. Strong IV: load combination to take into account the possibility of a large dead load to live load ratio.
5. Strength V: load combination related to the normal operation of the bridge by taking into account wind loads at speeds of 90 km/hour to 126km/hour.
6. Extreme I: the combination of earthquake loading, the live load factor which considers the operation of the live load during the earthquake must be determined based on the importance of the bridge.
7. Extreme II: load combination which considers the combination of reduced live load and the load arising from ship collision, vehicle collision, flooding or other hydraulic loads, except for the case of loading due to vehicle collision (TC). The case of loading due to flooding should not be combined with loads due to vehicle collisions and ship collisions.
8. Service I: a combination of loading related to bridge operations with all loads having a nominal value and taking into account the presence of wind loads at speeds of 90 km/hour to 126 km/hour. Combinations are used to contact deflection rollers and crack width
9. Service II: a combination of loading aimed at preventing the occurrence of yielding of the steel structure and slippage of the joints due to vehicle loads.
10. Service III: load combination to calculate tensile stress in the longitudinal direction of prestressed concrete bridges with the aim of controlling the magnitude of cracks and the main tensile stress in the body of the segmental concrete bridge.
11. Service IV: load combination to calculate tensile stress in prestressed concrete column with the aim of controlling the crack size.
12. Fatigue: combination of fatigue load and fracture related to fatigue life due to load induced indefinitely.

Table 1. Combination of Load and Load Factor

Keadaan Batas	*MS MA TA PR PL SH*	*TT TD TB TR TP*	*EU*	*EW_s*	*EW_L*	*BF*	*EU_n*	*TG*	*ES*	*Gunakan salah satu*		
										EQ	*TC*	*TV*
Kuat I	*P*	1,8	1,00	-	-	1,00	0,50/1,20	*TG*	*ES*	-	-	-
Kuat II	*P*	1,4	1,00	-	-	1,00	0,50/1,20	*TG*	*ES*	-	-	-
Kuat III	*P*	-	1,00	1,40	-	1,00	0,50/1,20	*TG*	*ES*	-	-	-
Kuat IV	*P*	-	1,00	-	-	1,00	0,50/1,20	-	-	-	-	-
Kuat V	*P*	-	1,00	0,40	1,00	1,00	0,50/1,20	*TG*	*ES*	-	-	-
Ekstrem I	*P*	*EQ*	1,00	-	-	1,00	-	-	-	1,00	-	-
Ekstrem II	*P*	0,50	1,00	-	-	1,00	-	-	-	-	1,00	1,00
Daya layan I	1,00	1,00	1,00	0,30	1,00	1,00	1,00/1,20	*TG*	*ES*	-	-	-
Daya layan II	1,00	1,30	1,00	-	-	1,00	1,00/1,20	-	-	-	-	-
Daya layan III	1,00	0,80	1,00	-	-	1,00	1,00/1,20	*TG*	*ES*	-	-	-
Daya layan IV	1,00	-	1,00	0,70	-	1,00	1,00/1,20	-	1,00	-	-	-
Fatik (TD dan TR)	-	0,75	-	-	-	-	-	-	-	-	-	-

Catatan : - dapat berupa *MS MA TA PR PL SH* tergantung beban yang ditinjau
- *EQ* adalah faktor beban hidup kondisi gempa

Source: SNI 1725-2016

Where :
MS = dead load of structural and non-structural components of the bridge
MA = pavement dead load and utility
TA = horizontal force due to earth pressure
PL = forces that occur in the structure bridge caused by implementation process, including all styles that occur as a result of changes statics that occur in segmental construction
PR = prestress
SH = force due to shrinkage/crawl
TB = brake force
TR = centrifugal force
TC = force due to vehicle collision
TV = force due to collision of ships
EQ = earthquake force
BF = friction force
TD = lane load “D”
TT = truck load “T”
TP = pedestrian load
SE = burden due to decrease
ET = force due to temperature gradient
EUn = force due to uniform temperature
EF = buoyancy
EWs = wind load on the structure
EWL=wind load on vehicle
EU = current load and drift

a. Live Loads

Live load, often known as applied load. Live loads are generally temporary, dynamic and subject to change. Examples of live loads are occupants, furniture and several other objects. The intensity of this load varies depending on a certain time, for example a building will experience an increase in live load during working hours on weekdays, and there will be a much smaller live load at night or on weekends. The live load can be concentrated or distributed, besides that the live load can increase due to vibration, impact, and acceleration. (Dipohusodo, 1999)

According to SNI 1725-2016 live loads are all loads originating from moving vehicles/traffic and/or pedestrians who are considered to be working on bridges.

Table 2. Number of Planned Traffic Lanes

Tipe Jembatan (1)	Lebar Jalur Kenderaan (m) (2)	Jumlah Lajur Lalu Lintas Rencana (n_l)
Satu Lajur	4,0 – 5,0	1
Dua arah, tanpa median	5,5 – 8,25 11,3 – 15,0	2 (3) 4
Banyak arah	8,25 – 11,25 11,3 – 15,0 15,1 – 18,75 18,8 – 22,5	3 4 5 6

CATATAN (1) : Untuk jembatan tipe lain, jumlah lajur lalu lintas rencana harus ditentukan oleh Instansi yang berwenang.
CATATAN (2) : Lebar jalur kendaraan adalah jarak minimum antara kerb atau rintangan untuk satu arah atau jarak antara kerb/rintangan/median dengan median untuk banyak arah.
CATATAN (3) : Lebar minimum yang aman untuk dua-lajur kendaraan adalah 6.0 m. Lebar jembatan antara 5,0 m sampai 6,0 m harus dihindari oleh karena hal ini akan memberikan kesan kepada pengemudi seolah-olah memungkinkan untuk menyiap.

Sumber : RSNI T02-2005

b. Dead Loads

Dead loads, often known as static or permanent loads, are the dominant loads with respect to the weight of the structure itself. The dead load will remain stationary and relatively constant over time. Examples of dead loads can include immovable equipment, weight of structural elements, permanent non-structural partitions, and so on. (Dipohusodo, 1999)

The dead load on the structure is calculated by adding up the weight of the specified structural material and its volume. In theory, this allows dead load calculations to be carried out with a good degree of accuracy. However, the structural design must be carried out with some estimates such as minimizing potential deflections, allowing a margin of error and allowing changes in structural properties from time to time. Thus in the design and design of the dead load on the structure will often far exceed the load experienced by the actual structure. (Dipohusodo, 1999)

Dead load is the weight collection of each structural and non-structural component. Each of these components must be considered as an integral unit of action when applying normal load factor and reduced load factor. The planner must use his expertise in determining these components.

Table 3. Fill Weight For Dead Load

No	Material	Filling weight (kN/m^3)	Density mass (kg/m^3)
1	Bituminous wearing surfaces	22,0	2245
2	Cast iron (cast iron)	71,0	7240
3	Compacted soil (compacted sand, silt or clay)	17,2	1755
4	Compacted gravel (rolled gravel, macadam or ballast)	18,8-22,7	1920-2315
5	Asphalt concrete (asphalt concrete)	22,0	2245
6	Lightweight concrete (low density)	12,25-19,6	1250-2000

7	Concrete f'c<35MPa	22,0-25,0	2320
	35<f'c<105MPa	22 + 0,022 f'_c	2240 + 2,29 f'_c
8	Steel (steel)	78,5	7850
9	Wood (light)	7,8	800
10	hard wood	11,0	1125

Source: SNI 1725-2016

Self-weight is the weight of the part and other structural elements it carries, including in this case the weight of materials and parts which are structural elements, plus non-structural elements which are considered fixed. (SNI 1725-2016).

Table 4. Load Factor for Self Weight

Load type	Load factor (^{S})*MS*			
	Service Limit (S)MS State (^{S})*MS*		Ultimate Limit (^{U})*MS*	
	Material		Ordinary	Reduced
Fixed	Steel	1,00	1,10	0,90
	Aluminium	1,00	1,10	0,90
	Precast concrete	1,00	1,20	0,85
	Concrete cast in place	1,00	1,30	0,75
	Wood	1,00	1,40	0,70

Source: SNI 1725-2016

Additional dead load is the weight of all materials that make up a load on a structure that is a non-structural element, and its magnitude can change over the life of the structure. (SNI 1725-2016)

Table 5. Load Factor for Additional Dead Load

Load type	Load factor (*MA*)			
	Service Limit State (^{S}) *MA*		Ultimate boundary state (^{U}) *MA*	
	Material		Ordinary	Reduced
Fixed	General	1,00(1)	2,00	0,70
	Special (supervised)	1,00	1,40	0,80
Note (1) : Service load factor of 1.3 is used for utility weight				

Source: SNI 1725-2016

c. Environmental loads

Environmental load is the type of load that can act on the structure due to environmental and weather conditions.

1. Wind loads

Wind loads can occur due to air movement relative to a structure, and analysis of wind loads refers to meteorology and aerodynamics and structures. Wind load may not be a significant loading problem especially for small or large sized structures, but it is very important to carry out wind load analysis especially in tall structures, the use of lighter materials and the shape of the structure will directly affect air flow, usually applies to the roof of a building. If the dead load on a structure is not sufficient to withstand wind loads, then additional structural analysis and fixation calculations are needed.

The wind speed used in calculating the design of building structures is usually determined based on historical records using extreme value theory, this is to predict unusual (extreme) wind speeds that may occur at an unexpected time.

The special effects of wind loads that need to be considered in the design of structural designs (Dipohusodo, 1999) are:

a) The angle of air flow that occurs around the corners of the building structure.
b) Vortex shedding that occurs in the building structure.
c) The flow path (Through-flow), which is the path of air/wind flow through the building or the gaps between the building structures.

In certain more complex conditions, it is necessary to conduct tests on the shape of the wind channel of the building structure to assess changes in air flow that occur due to the structure. However, if more parameters are taken into account, it is better to analyze using computational fluid dynamics software.

For normal conditions, the wind load is calculated at a minimum of 25 kg/m2. For buildings that are in special conditions (Dipohusodo, 1999) calculated as follows:

a) The inflatable pressure at the seaside up to 5 km from the coast must be taken at a minimum of 40 kg/m2.
b) For buildings where the possible blowing pressure is more than 40 kg/m2, it should be taken as V2/16(kg/m2), where V is the wind speed in m/s.
c) For chimneys, the internal blowing pressure shall be determined by the formula (42.5 + 0.6h), where h is the total chimney height in meters.

2. Earthquake Load

Significant horizontal loads can occur on structures during an earthquake. Building structures located in seismic activity areas (earthquakes) need to be analyzed and designed carefully to ensure that no structural failure occurs in the event of an earthquake.

Areas that are included in the earthquake path, the earthquake load must be calculated. Earthquake loads are all equivalent static loads acting on the structure due to the movement of the ground by an earthquake, both vertically and horizontally. However, in general, the ground acceleration in the horizontal direction is greater than the vertical direction, so the effect of horizontal motion is much more decisive.

The magnitude of the equivalent shear force is determined by the formula (Dipohusodo, 1999):

= ((C x I) / R) x Wt ....(2.1)

C = earthquake response factor (depending on the location and type of soil).
I = building priority factor.
R = earthquake reduction factor (depending on the type of structure).
Wt = total building weight including live load.

Besides being grouped by live load, dead load and environmental load. Loads can also be categorized based on SDL (Superimsod Dead Load) loads, traffic loads, and earth pressure loads.

For simple bridges, earthquake effects are calculated using the equivalent static load method. For large, complex and important bridges dynamic analysis may be required. The minimum seismic design load is obtained from the following formula (Dipohusodo, 1999): Where,

$$T^*_{EQ} = Kh/W_T \text{......................} \quad \mathbf{(2.2)}$$

$$Kh = C \cdot S \text{......................} \quad \mathbf{(2.3)}$$

Where:

T^*_{EQ}= The total base shear force in the direction under consideration (kN).

Kh = Coefficient of horizontal earthquake load.

C = Basic shear coefficient for the appropriate area, time and local conditions (RSNI T-02-2005).

I = Interest factor (RSNI T-02-2005).

S = Building type factor (RSNI T-02-2005).

WT= Total nominal weight of the building that affects earthquake acceleration, taken as dead load plus additional dead load (kN).

2.3 Structural Analysis

Structural analysis is the process of calculating and determining the effects of loads acting on structures (buildings, bridges, piers or other objects) that cause reactions in the form of internal forces on the structure. Structural analysis is very important to ascertain how the flow, distribution and impact of loads on the structure under consideration.

In addition to loads that affect the behavior of the structure are the materials used and the geometry (system) of the structure. By conducting a structural analysis, it can be seen how the behavior of the structure and its level of safety when subjected to the expected load will work. Structural Analysis can be carried out during the design phase, during testing and post construction.

Currently, almost all structural analysis is carried out using mathematical models that refer to the rules of mechanics, where the model can be elastic or inelastic, linear or non-linear, the force can be static or dynamic, and the structural model may be one-dimensional, two-dimensional or three dimension.

Analysis and modeling must also refer to applicable standard regulations. However, in some strategic projects, such as long span cable-stayed bridges, in addition to structural analysis using mathematical models, a scalar model is also made to verify whether the calculation analysis using the mathematical model matches the actual structure behavior.

a. Structure Material Properties

To carry out an accurate structural analysis, complete data on the properties of the materials used are essential. The data includes specific gravity, tensile strength, compressive strength, modulus of elasticity, poison ratio and others, where the data on the properties of the material are obtained through testing. Vendors providing concrete or steel have now included data sheets on the properties of the materials offered.

Table 6. Structure Material Properties

Bahan	Berat Jenis, γ (kN/m^3)	Massa Jenis, ρ (kg/m^3)	Modulus Elastisitas, E (GPa)	Modulus Geser, G (GPa)	Rasio Poisson, v	Tegangan Leleh, σ_L (GPa)	Tegangan Ultimate, σ_U (GPa)	Koef. Termal, α ($10^{-6}/^oC$)
Beton Biasa (Tekan)	23	2300	17-31		0.1-0.2		10-70	7-14
Beton Diperkuat (Tekan)	24	2400	17-31		0.1-0.2		10-70	7-14
Beton Ringan (Tekan)	11-18	1100-1800	17-31		0.1-0.2		10-70	7-14
Baja ASTM A36	77	7850	190-210	75-80	0.27-0.3	250	400	10-18
Baja ASTM A572	77	7850	190-210	75-80	0.27-0.3	340	500	10-18
Baja ASTM A514	77	7850	190-210	75-80	0.27-0.3	700	830	10-18

Source: https://hesa.co.id/analysis-structure/

Apart from the material properties, the strength of a structural element also depends on its dimensions and geometric shapes.

And of course the material used must comply with applicable regulatory standards. The following regulations regulate the provisions for the use of steel and concrete in structural design, among others:

1. SNI 2847-2013 Requirements for structural concrete for buildings,
2. SNI 2052-2014 Concrete reinforcement steel
3. SNI 1729-2015 Specifications for structural steel buildings.

b. How to Analyze Structure

The method used in conducting structural analysis, depends on the level of accuracy required. It can simply be broken down into:

1. Hand Calculation

   Simple hand calculation is a very fast and easy way of manual calculations to evaluate the effect of simple forces on simple structures. Such as calculating the bending moment, shear in a simple horizontal beam of a certain static structure (simple beam) or a continuous beam of an indeterminate static structure (continuous beam).

2. Finite Element Analysis

   Finite Element Analysis (FEA) is a complex numerical method used to solve complex problems containing a number of input variables such as boundary conditions, load applications, and support types.

   This is a much more complicated, but accurate method for performing structural analysis compared to hand calculations. FEA requires that the structure be broken down into smaller parts (or elements) that can be evaluated individually for a more accurate estimate of the solution.

   For the case of a simple structure FEA can still be calculated manually with the help of a calculator or spreadsheet although it will take longer time, but for large and complex structures the FEA model can consist of thousands of matrix entries so it is impossible to evaluate by human calculations.

   Today FEA is still a very powerful and accurate structural analysis method that is the basis of most Structural Analysis Software.

3. Structural Analysis Software

There are a large number of Structural Analysis Software that can perform accurate FEA calculations without the hassle of having to manually set up complex processes, such as ETABS, SAP2000, MIDAS, STAADPro, ABAQUS, SAFE, Tekla Structural Designer, S-FRAME ANALYSIS and others. The aim is to help make it easier for analysts to:

a) Modeling of structural materials, structural geometry, structural loading and other constraints determined by the engineer,
b) Perform calculations and analysis of internal forces on structural elements due to loads and combinations of working loads and
c) Assist in checking element strength at the design stage.

2.4 SAP 2000

SAP 2000 is a program for calculating the strength of structures, especially high-rise buildings and bridges. This program is of great interest to all civil engineers because it is very easy to learn and simple to use. Imagine before the SAP 2000 program, civil engineers often used structural analysis formulas which took a long time. After the existence of this program can accelerate the results of the analysis. The performance of SAP 2000 is to create structural models or building portals. Then given work loads such as live loads, dead loads, earthquake loads, wind loads and so on. The output of this program is the moment, shear force, and normal force required for the purposes of designing the reinforcement requirements for structural elements (Ikhrom Basori, 2018).

a. History and Development of SAP 2000

SAP2000 was developed based on the SAP1 program around 1975. The SAP1 program is a computer program created by Prof. Edward L. Wilson, professor at the University of California, Berkeley, California, USA. In 1975, a commercial version of the program was launched by the company Computer and Structure Inc. (CSI) led by Ashraf Habibullah. Until now, the program is known worldwide as a pioneer in the field of seismic and structural engineering software. As software that grew up in a university environment, many studied the program's source code and became the forerunner of other similar structural analysis programs (Wiryanto Dewobroto, 2013).

Currently, CSI software has been used in more than 160 countries and is used for planning large projects such as the Taipei 101 Tower (Taiwan), One World Trade Center (New York), Birds Nest Stadium (Beijing), and the Cable-Stayed Centenario Bridge. crossing the Panama Strait. Initially the SAP program was made for main-frames. The PC version of the SAP program was released in 1980, namely SAP80 and in 1990 it became the SAP90 version. Everything in the DOS operating system. The characteristics of the operating system is to use files to enter data input. When the PC switches from DOS (text) to Windows (graphics), the SAP2000 version is issued. Currently the latest PC version is SAP2000 v 15.00 (Wiryanto Dewobroto, 2013). This version is quite sophisticated because it can be used to perform non-linear analysis (large deformations, gaps/contacts), cables, explosive loads and construction stages. But for simple cases (general) between the old and new versions of the program do not give a significant difference, even tend to be exactly the same.

b. SAP 2000's Usability and Capabilities

As one of the software used by civil engineering, SAP 2000 can help in planning building structures (Ikhrom Basori, 2018) which include:

1. calculate the moment of engineering mechanics on the building structure,
2. calculate the steel construction (columns, beams, and floor slabs) and
3. calculate steel construction.

The main principles of using this program are structural modeling, analysis execution, and inspection or design optimization; which is all done in one step or view. The display is in the form of a model in real time, making it easier for users to do comprehensive modeling in a short time but the results are accurate. Some of the capabilities of this program (Ikhrom Basori, 2018) include:

1. fast and accurate analysis,
2. More accurate shell element modeling,
3. dynamic analysis with Ritz and Eigenvalue,
4. Multiple coordinate systems for complex structural geometric shapes and a more complete loading model in the form of static loading and dynamic loading.

This software does not limit the analysis capacity so that it can be applied to even complex forms. Equipped with bridge structure analysis with moving loading, and analysis options with time history that can be adjusted to certain regional conditions. The effect of subgrade motion can also affect the modeled structure.

III. Research Method

3.1 Types of Research

This type of research is a quantitative description that makes a condition on an object of research and focuses on one particular object by analyzing it as a case, and the conclusions obtained are in the form of factual, systematic and accurate events or descriptions and only apply to companies with development projects under study**.**

3.2 Research Sites

This box traffic/underpass study took place on the Kuala Tanjung – Indrapura toll road Section II Zone 2 STA 14+777 Batubara district, North Sumatra province which was planned by PT Waskita which was on the Sumatra Indrapura cross road, Batubara district, North Sumatra province.

Source: www.google.com/maps/search/

Figure 1. *Project Location*

3.3 Research Subjects and Objects

a. The subject of this research is the report on the construction planning of the box traffic/underpass on the Kuala Tanjung – Indrapura Toll Road Section II Zone 2 STA 14+777.
b. The object of this research is the analysis of the box traffic/underpass structure loading on the Kuala Tanjung – Indrapura Toll Road Section II Zone 2 STA 14+777.

3.4 Primary Data

In order to assist the calculation of this analysis, it takes some primary data obtained from companies consisting of: :

a. Dimensions of Traffic Box/Underpass

1.	Width of Traffic Box	5,10 m
2.	Traffic Box Height	5,00 m
3.	Length of Traffic Box	9.00 m
4.	Floor plate thickness	0,80 m
5.	Thickness of wall plate	0,80 m

b. Wing wall dimensions

1.	Wing Wall Length	15,6 m
2.	End Wing Wall Height	6,35 m
3.	Wing Wall Thickness	0,5 m

c. Concrete quality

1.	K concrete	250
2.	Fc'	20.75 Mpa
3.	Ec	1409518.91 kN/m2
4.	Ɛc	0.003
5.	$\beta 1$	0.850

d. Reinforcement Data

1.	Fy	400 Mpa
2.	Es	200000 Mpa
3.	Ɛs	0.002

e. Reduction Factor (ϕ) SNI 02

1.	Bending	0.80
2.	Slide	0.75
3.	Torque	0.75
4.	Press + Bending Spiral	0.70
5.	Press + Flex stirrup	0.60
6.	Tensile + Bending	0.80

f. Load Data

Based on the SNI 1725-2016 Bridge loading regulations, the following loads will be used on the box traffic structure:

1.	Self weight	106,46 kNm
2.	traffic load	UDL = 9 kN/m^2

		KEL = 49 kN/m^2 FBD = 1,4 x KEL = 68,6 Truck Axle = 112,5 kN
3.	Ground Pressure Load	475,44 kNm

3.5 Method of Collecting Data

a. Interview

Is one way to collect information by asking and answering face to face with respondents about the company's activities carried out by the executor and who is responsible for the structural planning process.

b. Documentation

Represents data obtained from historical records and documents including the design and dimensions of the planned traffic/underpass box.

3.6 Data Analysis Method

Based on the formulation of the problem that has been described in CHAPTER I, it is necessary to prepare the stages of problem solving, including the following:

a. Identify the problem

The first step is to identify the problem, which is about box traffic/underpass planning data.

b. Determination of analysis method

In this stage determine the method used when analyzing the data that has been identified previously.

c. Data analysis

After being identified and selecting the analytical method used, the next step is to analyze the data.

d. Results of data analysis

Then the last stage is the presentation of the results of data analysis that has been analyzed.

3.7 Research Flowchart

In order for the research implementation process to be carried out properly according to the aims and objectives, it is necessary to make a research flow chart that serves as a guide in carrying out this research. Therefore, the arrangement of the research flow diagram to be carried out is as follows, which can be seen in Figure 2 below.

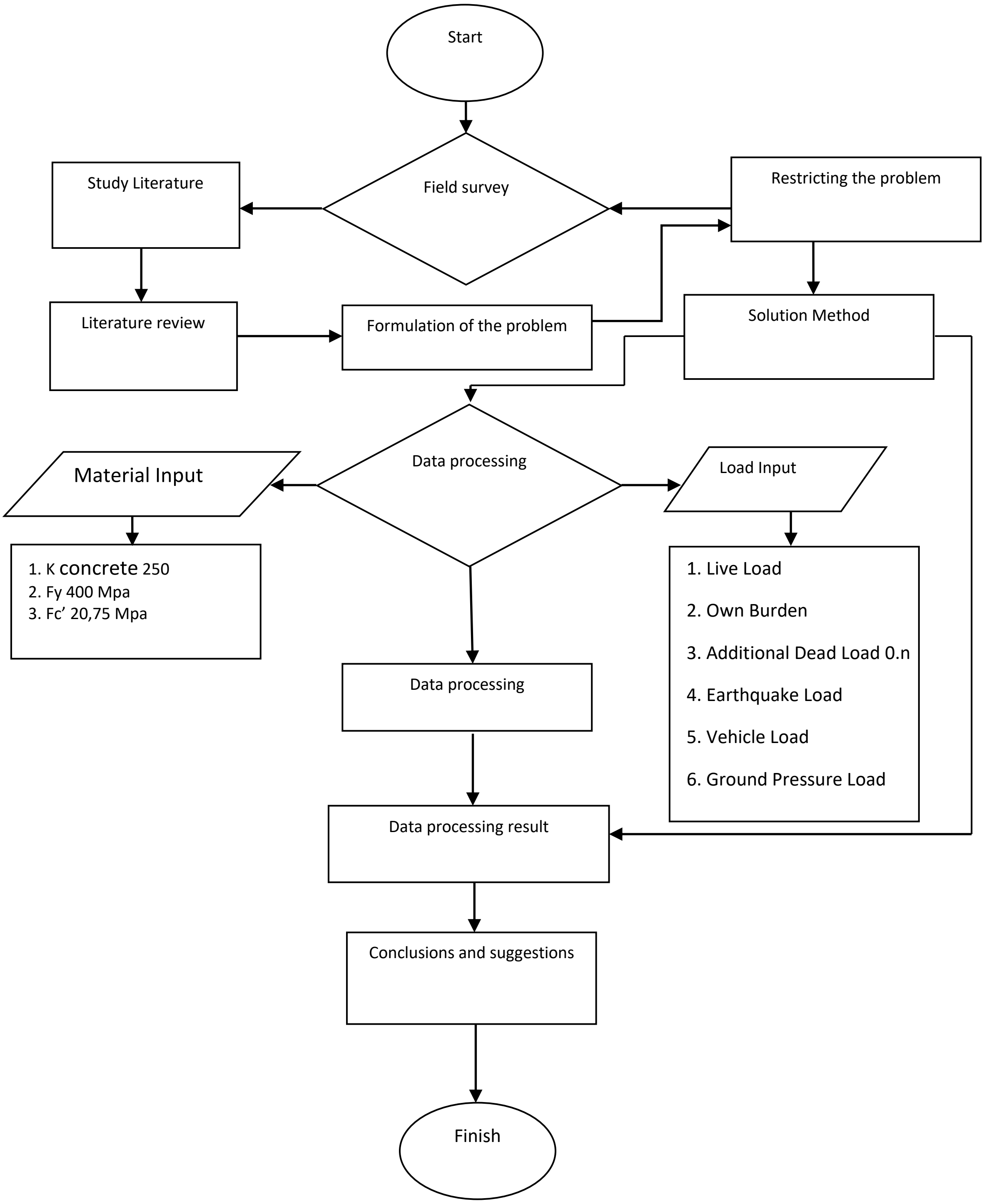


Figure 2. *Research Flowchart*

IV. Results and Discussion

4.1 Loading Analysis

a. Self Weight (MS)

Self weight is the weight of the material and part of the box traffic/underpass which is a structural element, plus the non-structural elements it carries and is fixed. The own weight of the traffic box is calculated by looking at a width of 1 m (perpendicular to the bid. image).

Known Quality of Concrete K-250.

Then the weight of concrete with K-250 = 250kg/

= 25 kNm

So the self-weight of the structure is as follows:

1. Self weight of Floor slab = 20 kNm

   Total self weight of floor slab = 16 kN/

2. Wall plate self weight

   = 40 kNm

Total self weight of wall plate = 64 kN/

As for the ultimate load factor itself is = 1.3

b. Additional Dead Load (MA)

Dead load is the weight collection of each structural and non-structural component. In this case, the dead load density (according to table 7) is:

Table 7. Fill Weight Additional Dead Load

Material	**Filling weight (kN/m^3)**	**Density mass (kg/m^3)**
asphalt concrete	22,0	2245

As for the ultimate load factor itself is = 2.0

c. Traffic Load

For the price, L = 9.00 then DLA = 0.4

live load on the floor,

Q_{TD}	=	8,00	kN/m
P_{TD} = (1 + DLA) x p	=	68,6	kN

As for the ultimate load factor itself is = 2.0

Truck Load “T” (TD)

The live load on the floor of the bridge is in the form of a double wheel load by a truck (load T) whose magnitude, T = 112.5 kN.

Dynamic load factor for truck loading taken(DLA) = 0.40

Truck load"T"(PTT) = 157.5 kN

Due to load"D" MTD = 9.2 kNm

Due to load"T"MTT = 19.6kNm

For traffic loading, the "T" load is used which gives a greater moment effect than the "D" load (MTD < MTT).

As for the ultimate load factor itself is = 2.0

d. Ground Pressure Load

On the part of the soil behind the abutment wall which is burdened by traffic, it must be taken into account that there is an additional load equivalent to 1 m of soil in the form of a uniform load equivalent to the vehicle load on that section. Then obtained a large 475.44 kNm. As for the ultimate load factor itself is = 1.25.

e. Environmental Load

The environmental load itself consists of wind loads and earthquake loads. In this case the two loads above only have their own ultimate factor value, namely:

1. Wind load = 1,20
2. Earth quake load = 1,20

4.2 Loading Combination

From the calculation results of all loadings in the previous discussion, the following is a table of load combinations that occur in the box traffic/underpass structure.

Table 8. Loading Combination

No.	Type Loading	Factor Loading	Comb-1	Comb -2	Comb -3
1.	Self Weight	K_{MS}	1,3	1,3	1,3
2.	Additional Dead Load	K_{MA}	2,0	2,0	2,0
Traffict Load					
3.	Lane Load "D" (TD)	K_{TD}	2,0	1,0	
4.	Truck Load "T" (TT)	K_{TT}	2,0	1,0	
5.	Ground Pressure Load	K_{TA}	1,25	1,25	1,25
Environmental Burden					
6.	Wind load	K_{EW}	1,0	1,2	
7.	Earthquake load	K_{MS}			

So the calculation for the combination of loading that occurs in box traffic/underpass is as follows:

a. Loading Combination 1

1. Self Weight
   Weight of floor slab
   = 20.8kN/
   Self weight of wall plate
   = 83.2kN/
2. Additional Dead Load
   = 4.8 kN/
3. Line Load "D" (TD)
   = 18.4 kN/
4. Lane Load "T" (TT)
   = 39.2 kN/
5. Ground Pressure Load
   = 66.03 kN/

b. Loading Combination 2

1. Self Weight
   Weight of floor slab = 20.8 kN/
   Self weight of wall plate = 83.2 kN/
2. Additional Dead Load = 4.8 kN/
3. Line Load “D” (TD) = 18.4 kN/
4. Lane Load “T” (TT) = 39.2 kN/
5. Ground Pressure Load = 66.03 kN/

c. Loading Combination 3

1. Self Weight
   Weight of floor slab = 20.8 kN/
   Self weight of wall plate = 83.2 kN/
2. Additional Dead Load = 4.8 kN/
3. Ground Pressure Load 25 = 66.03 kN/

Show Forces/Stresses

This menu is used to display the loading experienced by the structure.

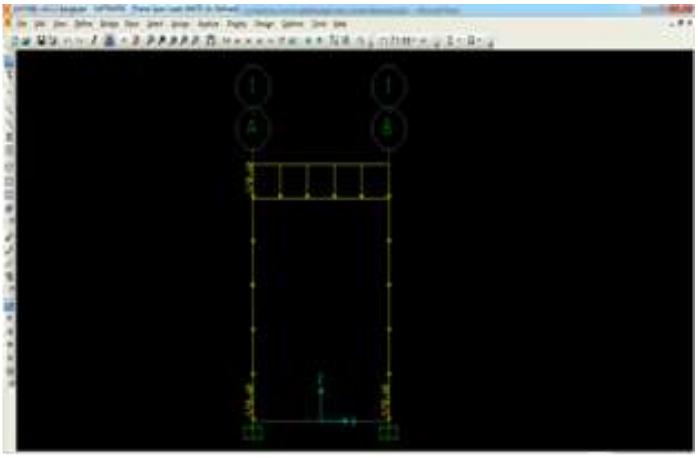
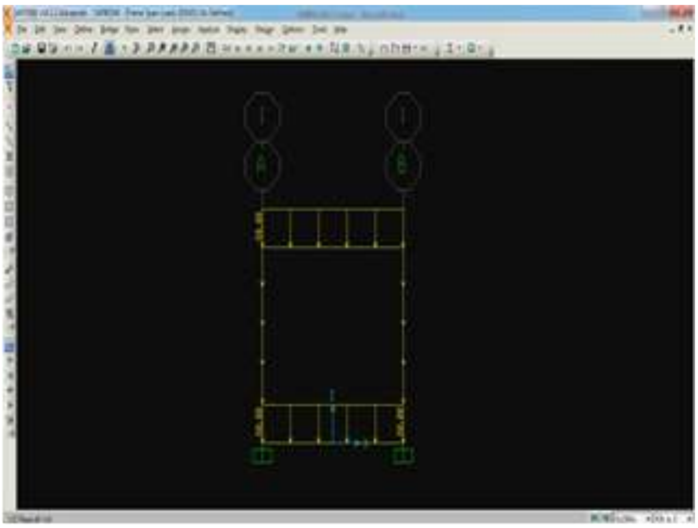


Figure 3. *Dead Load*



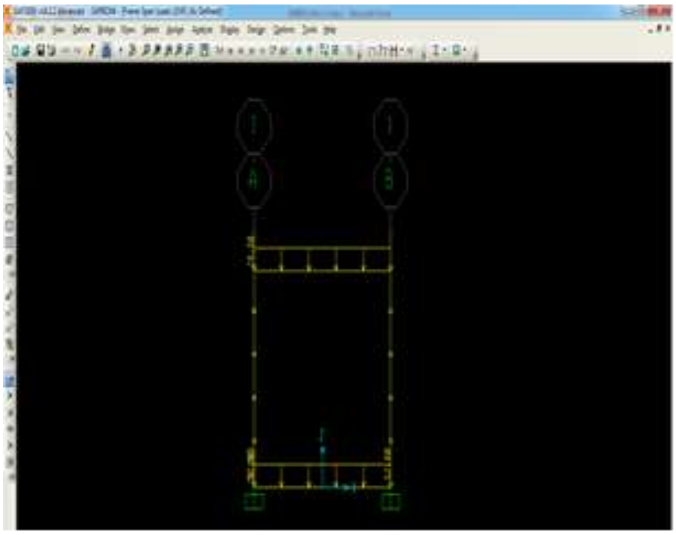


Figure 4. *Live Load*

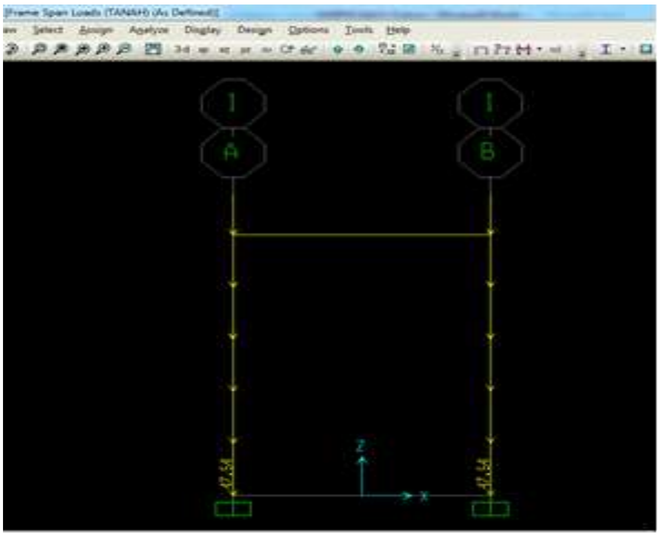


Figure 5. *Ground Pressure*

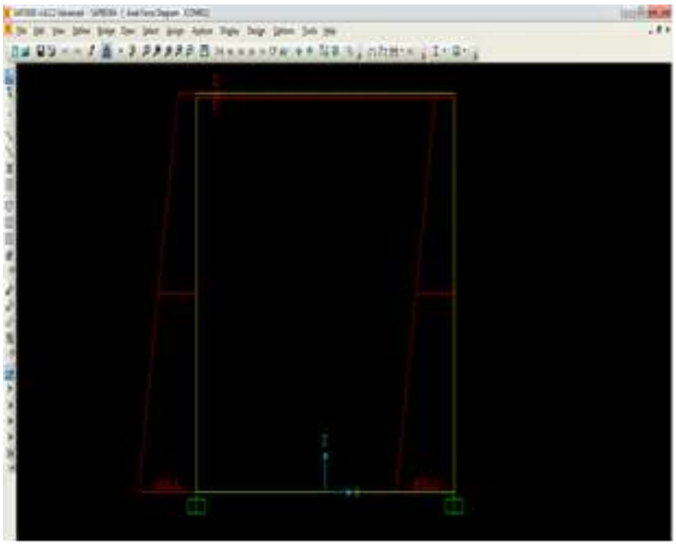


Figure 6. *Axial Combination 1*

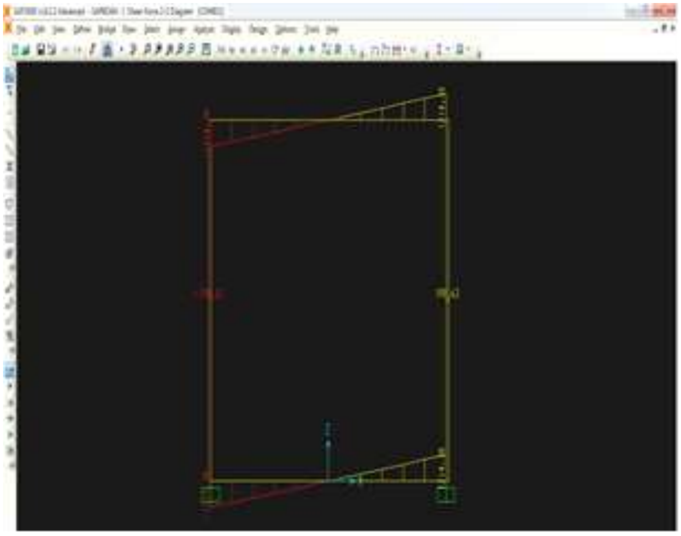


Figure 7. *Slide Combination 1*

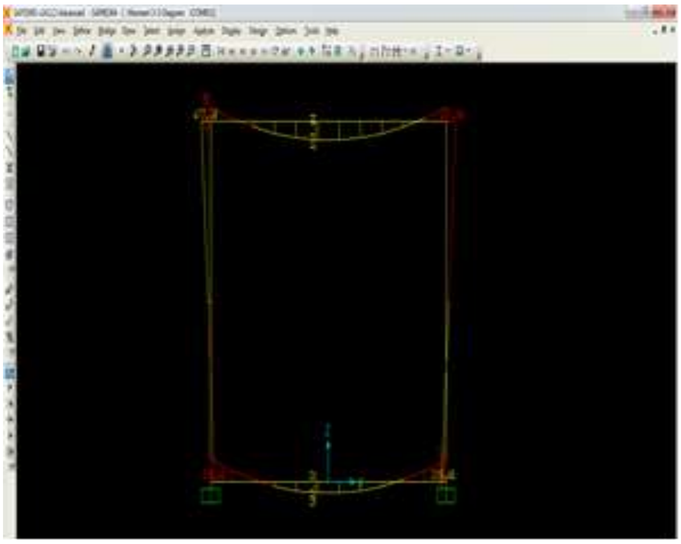


Figure 8. *Combination Moment 1*

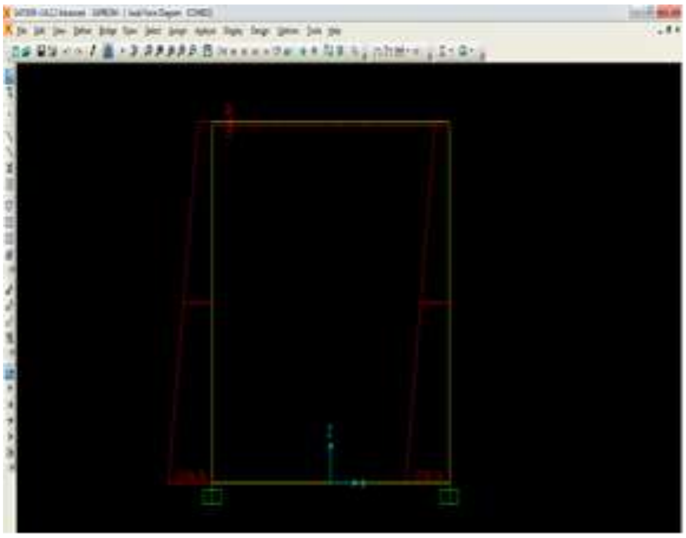


Figure 9. *Axial Combination*

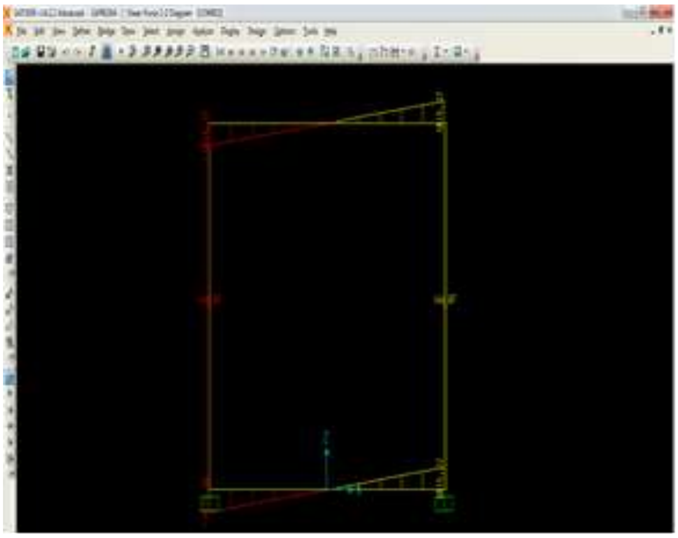


Figure 10. *Slide Combination 2*

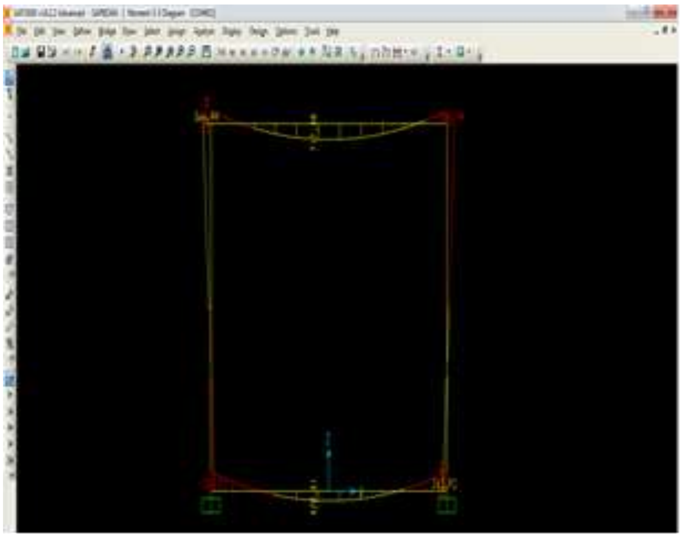


Figure 11. *Combination Moment 2*

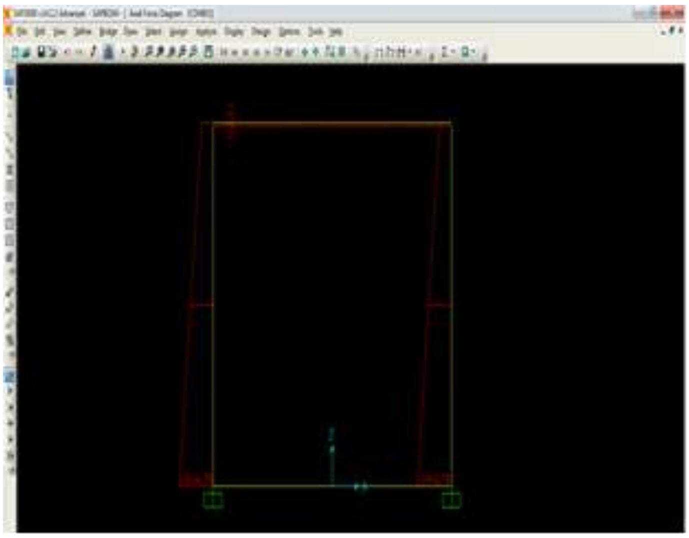


Figure 12. *Axial Combination 3*

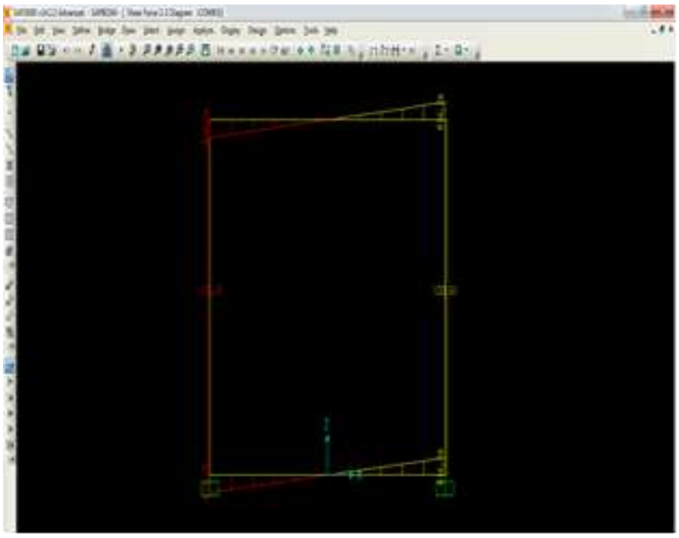


Figure 13. *Slide Combination 3*

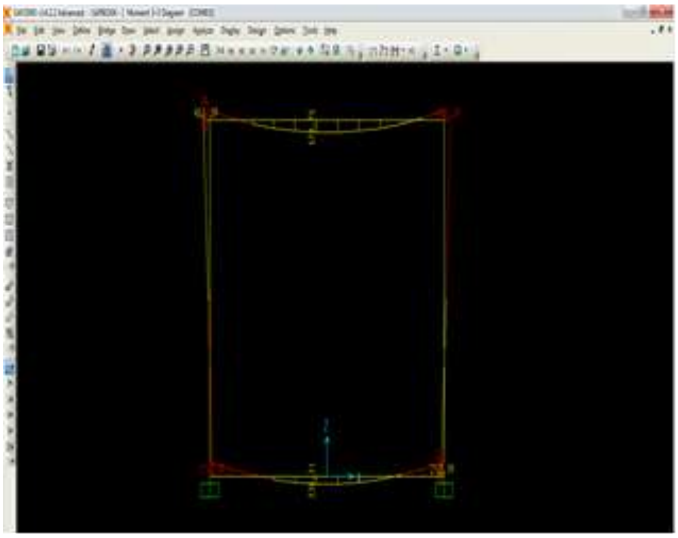


Figure 14. *Combination Moment 3*

V. Conclusion

After analyzing and designing using the SAP 2000 Program on the BOX TRAFFIC/UNDERPASS Building on the Kuala Tanjung – Indrapura Toll Road Section II Zone 2 which is adjusted to the Procedure for Calculation of the Bridge Loading Regulations according to SNI 1725-2016 and RSNI T-02-2005, based on structural analysis which is reviewed, it can be concluded that in the planning of box traffic/underpass, it is in accordance with the standard of bridge loading planning.

References

Asroni, Ali. *Balok Pelat Beton Bertulang*. Yogyakarta: Graha Ilmu, 2010.
Badan Standar Nasional. 2005. *Pembebanan untuk jembatan*. RSNI T-02-2005.
Badan Standar Nasional. 2016. *Pembebanan untuk jembatan*. SNI 1725-2016.

Bashori, Ikrom. 2019. *"Evaluasi Kinerja Seismik Struktur Bangunan Gedung. Bertingkat Menggunakan Pushover Analysis Dengan Capacity Spectrum Method"* Universitas Teknologi Yogyakarta.

Burhani Yasser Et. Al., 2017. *Perencanaan Box Culvert Dan Pintu Air Tambahan Pada Pintu Air Manggarai*, Jakarta Selatan, *Jurnal Karya Teknik Sipil,* Volume 6, Nomor 1, Tahun 2017.

Cook, Ronald A. 2002. *Design Live Loads on Box Culvert*. University of Florida.

Craig, Robert F., 2003, *Craig"s Soil Mechanics*, London: Spon Press.

Das, Braja M., 2014, *Principles of Foundation Engineering*, Boston: Cengage Learning.

Dewobroto, Wiryanto. 2007. *Komputer Rekayasa Struktur dengan SAP2000*. Dapur Buku.

Departemen Pekerjaan Umum, 1987, *Pedoman Perencanaan Pembebanan Jembatan Jalan Raya*, Jakarta.

Departemen Pekerjaan Umum, 1992, Bridge Management System – Peraturan Perencanaan Teknik Jembatan, Jakarta.

Dipohusodo, Istimawan. 1999. *Struktur Beton Bertulang*. Jakarta. PT Gramedia Pustaka Utama.

Dewi Eka Sari., 2011. *Analisa Risiko Pada Pelaksanaan Proyek Pembangunan Box Culvert Di Surabaya Jurnal Karya Teknik Sipil.*

E. Bowles, Joseph. 1991. *Sifat-Sifat Fisis Dan Geoteknis Tanah* (Mekanika Tanah). Jakarta. Erlangga.

Iqbal, Agus. 2015. *Dasar-Dasar Perencanaan Jembatan Beton Bertulang*. Jakarta PT Mediatama Saptakarya.

Magdalena, S., Suhatman, R. (2020). The Effect of Government Expenditures, Domestic Invesment, Foreign Invesment to the Economic Growth of Primary Sector in Central Kalimantan. *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*. Volume 3, No 3, Page: 1692-1703.

Maulana, Sayid Achmad., 2012. *Jurnal Perhitungan Struktur Box Culvert Pada Ruas Jalan Pulau Kalimantan Kecamatan Sebulu.*

Shah, M. M., et al. (2020). The Development Impact of PT. Medco E & P Malaka on Economic Aspects in East Aceh Regency. *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*. Volume 3, No 1, Page: 276-286

Sugiharto, Mochamad (2009) *Pengaruh pembangunan underpass ciledug thd kinerja jalan dan simpang*