Technical-descriptive report “Pre-design of proposed interventions for the improvement of transport and logistics in Paramaribo”.

Mexico City, February 2019

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1. Introduction

To carry out this pre-design, a traffic and microsimulation study was previously carried out, which provided the recommendations or interventions necessary to improve transportation and logistics in Paramaribo. The study determined to perform a 3 km road enlargement over the so-called "main corridor" conformed by Martin Luther Kingweg and Van´t Hogerhuysstraat. Also, the design contemplates interventions in another 4.4 km of secondary streets to provide an adequate operation of the corridor:

- Latourweg,
- Toekomstweg,
- Industrieweg Zuid,
- Industrieweg Noord,
- Slangenhout St,
- Jules Wijdenboschbrug,
- Willem Campagnestraat,
- Molenpad
- Kankawastraat

The corridor is designed to revitalize the public space, incorporating 9,274 km of bike lanes, 14. 8 km of sidewalk and 6.8 km of drainage works. The pre-design was made through documentary information provided by the Inter-American Development Bank and government ministries of Surinam; the cartography of the aforementioned roads was obtained by drone flights.

2. Objective

This document and its annexes (plans, graphs or images) are intended to generate, at the pre-design level, a comprehensive solution of physical interventions on access roads to the port to improve transportation and logistics in Paramaribo.

3. Methodology

To develop the pre-design, the following disciplines were integrated:

- Photogrammetry.
- Geometric Preliminary Project
- Public Space Preliminary Project.
- Pavement Preliminary Project
- Major Works Preliminary Project (Vehicular Bridge).
- Road Signaling
- Complementary Sewerage and Induced Works Preliminary Project.
  - Storm Sewer Preliminary Project
  - Sanitary Sewerage Preliminary Project
  - Street lighting Preliminary Project

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- Drinking Water Preliminary Project
- Cost of the works.

Since the documentary information provided does not have enough detail about underground public utilities, only 1 km of pre-design of the following items was developed covering the necessary elements to estimate total cost:

- Public Lightning Preliminary Project
- Drinking Water Preliminary Project
- Storm Sewer Preliminary Project
- Sanitary Sewerage Preliminary Project

3.1 Data Collection

The cartography was carried out with state-of-the-art technology through a drone, the survey was supported by topographic equipment and specialized software for photogrammetric restitution.

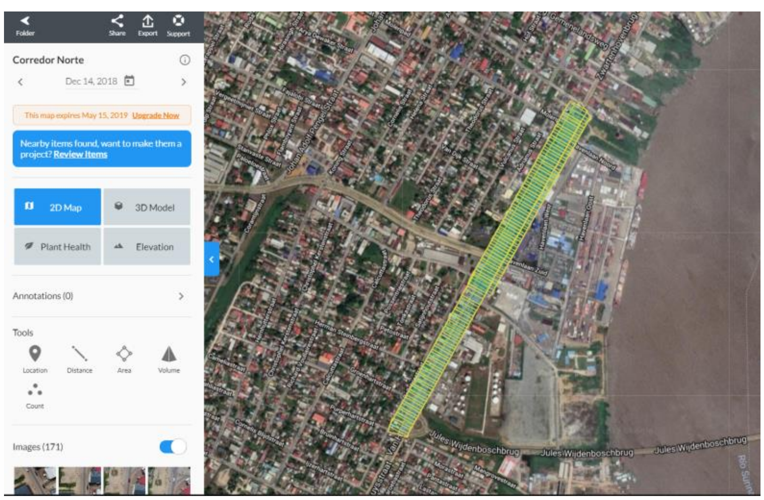
From the photogrammetric restitution, a cloud of points and the orthophoto were obtained; with these elements, the topography of the roads of study identifying existing infrastructure and identification of water bodies.

The methodology used to perform the drone surveying consisted in the execution of the following activities:

3.1.1 Traffic counts

This was performed using the DroneDeploy software, divided into 10 flights with 21 topographic control points.

Figure 2. Flight planning with DroneDeploy.



Source: Transconsult, based on DroneDeploy image

3.1.2 Topographic control points

21 land control points were proposed, which allowed airborne data triangulation during photogrammetric processing. These control points were first located using Google Earth and a drone test flight to verify their visibility. Subsequently, each point in the field was surveyed by topographic GPS, obtaining the X, Y, Z coordinates based on the UTM system.

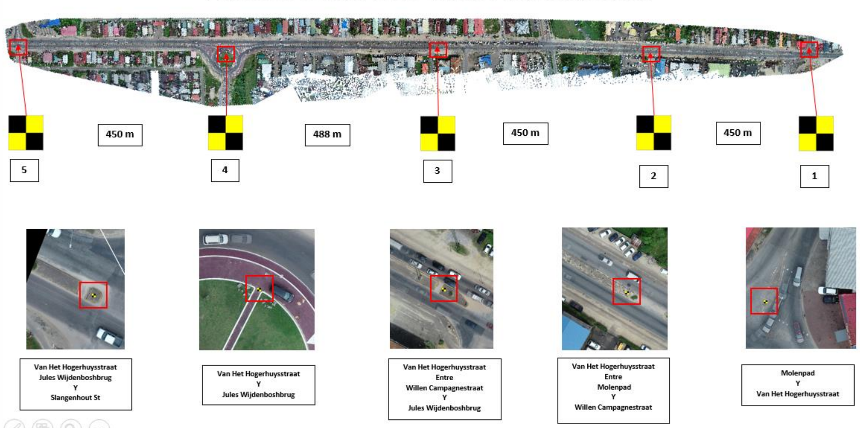
Figure 3. Location of control points in Google Earth.

Source: Transconsult, based on Google Earth image.

Figure 5 shows the physical mark placed in the field with its UTM coordinates.

Figure 4.- Location of control points in photos taken by drone.

Puntos de Control Vuelo Van Het Hogerhuysstraat



Source: Transconsult, based on images captured by the drone.

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Figure 5. Location of control points in the field

Source: Transconsult, based on images captured by the drone.

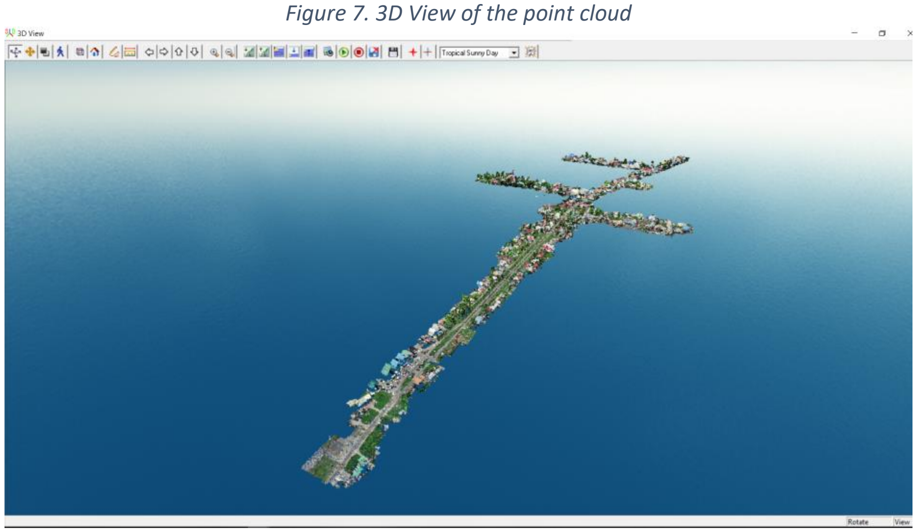
3.1.3 Photogrammetric restitution

From the images captured by the drone, with the corresponding ground support, the Orthophoto and the point cloud were obtained.

Figure 6. Orthophoto obtained from the photogrammetric restitution.

Source: Transconsult, based on images captured by the drone, (See appended orthophoto 1.0 Photogrametry folder appended).

Figure 7. 3D View of the point cloud

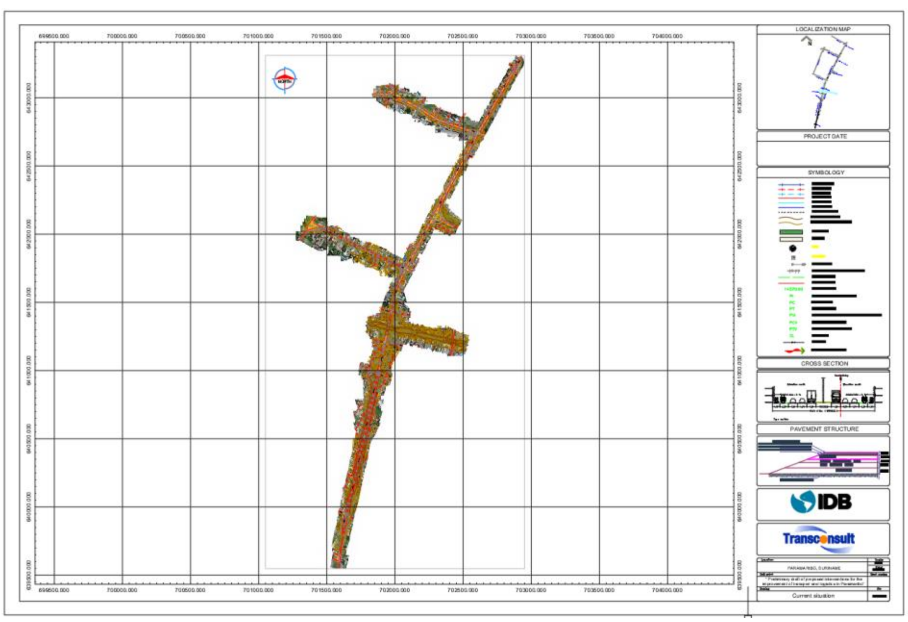


Source: Transconsult, based on images captured by the drone.

The orthophoto and the points cloud allowed generating the topography, by photogrammetric restitution. This allowed the identification of urban infrastructure elements:

a) Geometric situation of the roads under survey
b) Paved surface
c) Sidewalks
d) Sewerage elements (Manholes)
e) Electric distribution towers
f) Neglected public space areas

Figure 8.- Topographical plant



Source: Transconsult, based on images from AutoCad Civil 3d (see appended plan “Current situation”).

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3.2 Geometric Preliminary Project

The geometric design criteria for pre-design are based on the following urban and road design manuals:

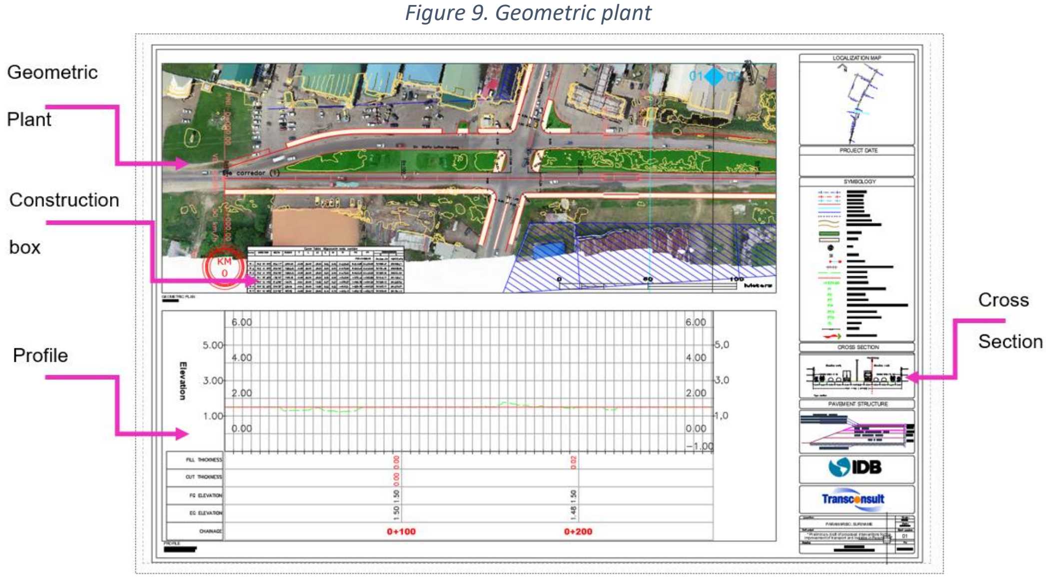
- AASHTO (2011) A Policy on Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials, Washington DC.
- Manual of geometric highway project 2018 of the Ministry of Communications and Transportation in Mexico (SCT).

The pre-design was made for a project speed of 50 to 60 km/h. The vehicular traffic lanes as well as the sidewalks are 3 meters wide, and 2.2 meters in bicycle lanes.

The pre-design in general is solved according to the current geometry of the main corridor and secondary streets, the existing horizontal and vertical curves were preserved as much as possible.

Figure 9 shows the components of the geometric plant generated for each axis of the corridor.

Figure 9. Geometric plant



Source: Transconsult, based on images from AutoCad Civil 3d (see appended plan "Desing Geometric and Profile").

The plans of the geometric design are located in the *3.0 Preliminary design geometric* folder, in file *SURI_PG* (Appended to this technical report).

3.2.1 Trace axes

The proposal is composed by 9 trace axes, with the corridor formed by the roads Martin Luther Kinweg and Van't Hogerhuysstraat as main axis, with 3.8 km length.

Figure 10. Main Corridor axis

Source: Transconsult, based on images from AutoCad Civil 3d (see appended plan "Desing Geometric and Profile").

The other 8 axes called auxiliary axes correspond to the secondary roads that interact directly with the main corridor.

Table 1. Axes in secondary streets.

Auxiliary axis	Length in meters
Latourweg	108.54
Toekomstweg	254.09
Industrie Zuidweg	190.00
Industried Noordweg	191.14
Slangenhout	682.93
Jules Wijdenboschbrug	281.06
Willem Campaganestraat	867.00
Hernehutter	1,187.58
Molenpad	680.00

Source:Transconsult, based on pre-design.

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Figure 11. Axes in secondary streets.

Source: Transconsult, based on images from AutoCad Civil 3d (see appended plan “Desing Geometric and Profile”).

The design of the horizontal alignment is adjusted to

- Right of way Available
- posts and towers of high and medium voltage
- Private property

Therefore, there are critical sections that require specific adjustments, which should be corrected in final design with detailed topography. There are two critical sections located in the 1+200 to 1+520 sections and 1+700 to 2+320.

Figure 13 shows that, in order not to affect the high voltage towers in the 1+200 to 1+520 section; it was projected with two traffic lanes in each direction and a central lane that will have the function of a reversible lane. The towers confine the section and do not allow keeping the 6 lanes without moving the towers or acquisition of right of way.

Figure 13. Reversible Lane.

Source: Transconsult, based on images from AutoCad Civil 3d (see appended plan “Desing Geometric and Profile”)

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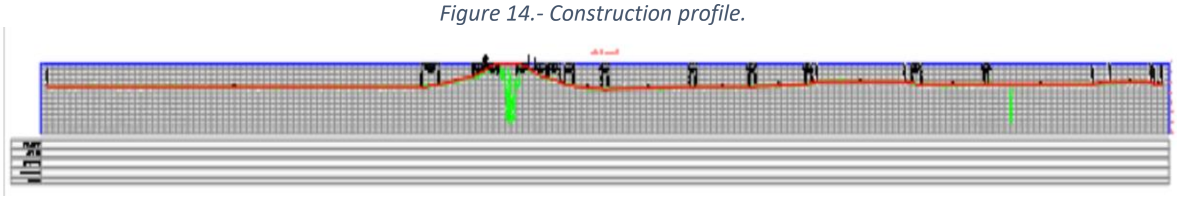
3.2.2 Longitudinal profile

The pavement grade design is adjusted to the current level of the roads; it is noteworthy that for the construction of the project, the detailed topography should be conducted, to adjust and fine-tune the final project.

Figure 14.- Construction profile.



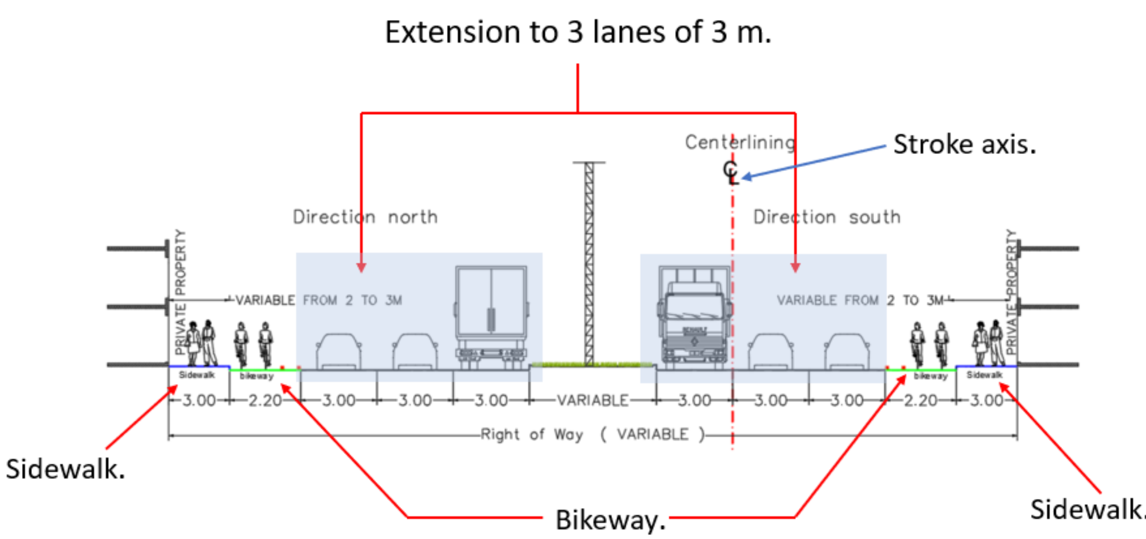
Source: Transconsult, based on images from AutoCad Civil 3d (see appended plan "Desing Geometric and Profile").

3.2.3 Typical design section and construction sections

The typical design section is composed of:

- 3 lanes, 3-meters wide by each direction,
- 1 bikeway per direction
- 3-meters wide sidewalks.

Figure 15.- Typical design section.



Source: Transconsult, based on images from AutoCad Civil 3d (see appended plan "cross section").

The construction sections contain the proposed pavement structure (which will be discussed in its correspondent section). These sections allow obtaining the volumes of soil and pavement required for the implementation of proposals.

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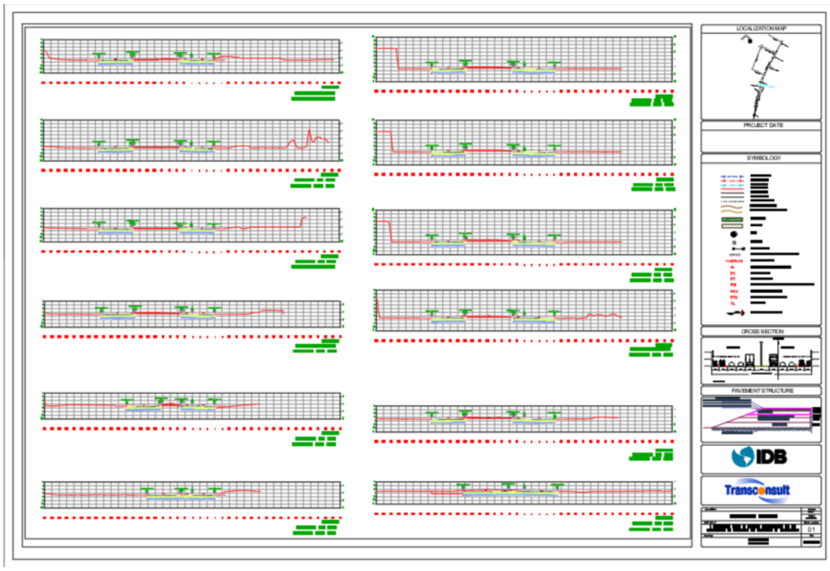
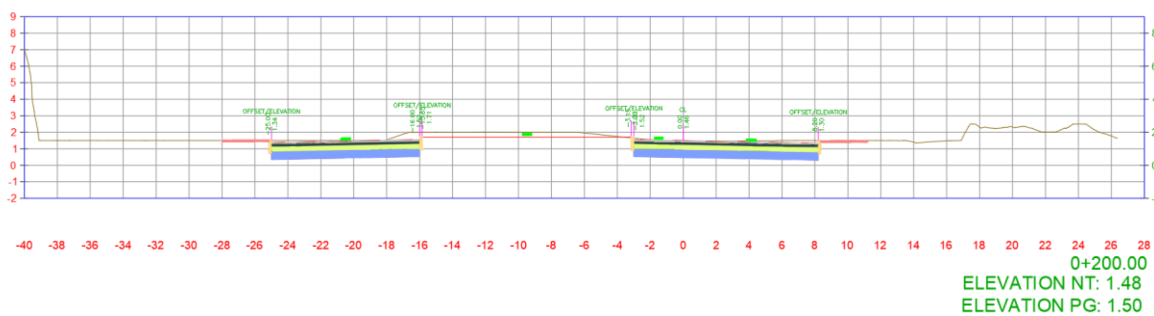
Figure 16. Construction sections plan of the main corridor.



Source: Transconsult, based on images from AutoCad Civil 3d (see appended plan “cross section”).

Figure 17.- Construction sections plan of the main corridor.



Source: Transconsult, based on images from AutoCad Civil 3d (see appended plan “cross section”).

3.3 Public Space Preliminary Project

The public space is every place outside of private property; that is, any space in the city outside of homes, businesses, institutions, etc.

The main corridor connects the city from north to south, serving as a primary road to access employment area in downtown. it does not have a pedestrian-friendly infrastructure since there is no proper sidewalks and or bike lanes. Right of ways is used as parking lots for housing and shops along the corridor. See Figure 18. Roundabout in Van't Hogerhuysstraat.

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Figure 18. Target Figure

Source: Transconsult, based on images captured by the drone.

The design of public space is intended to guarantee the safety of people moving either by foot,

Pre-design for the use of the Wetland and the green area that borders the current Jules Wijdenboschbrug road was developed, incorporating it directly into the public space, becoming an area for leisure and recreation focused on rescuing the wetland.

Figure 19 shows the pre-design of the current roundabout that forms the road Van't Hogerhuys St. with Jules Wijdenboschbrug.

Figure 19. Target Figure

Source: Transconsult

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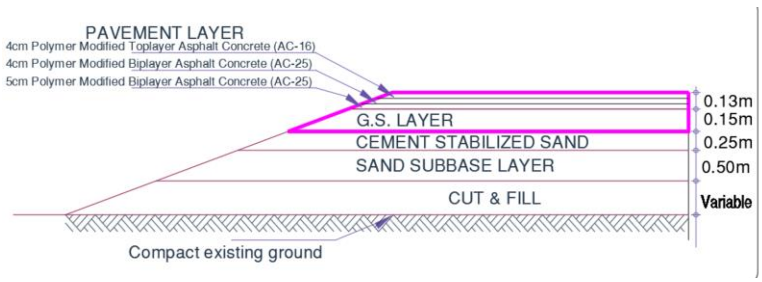
3.4 Pavement Preliminary Project

The proposal of pavements is focused on allowing the circulation of heavy vehicles over the main corridor.
It is noteworthy that this pavement design was based on documentary information from projects carried out for roads near to the study area.
From the above, two alternative solutions are presented.

- Structure 1. This pavement structure was used to draft the main corridor, which will allow the circulation of heavy vehicles.

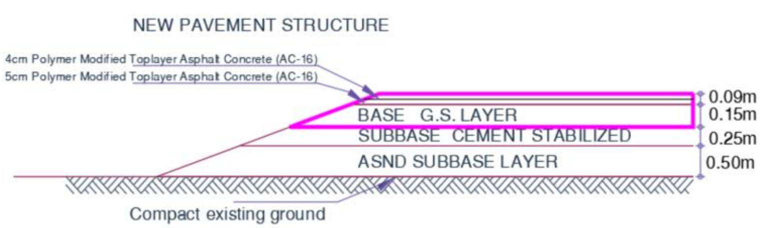
Figure 20. Pavement Structure 1



Source: Documentary information provided by the client.

- Structure 2. This pavement structure was used to draft extensions in secondary roads and bikeways.

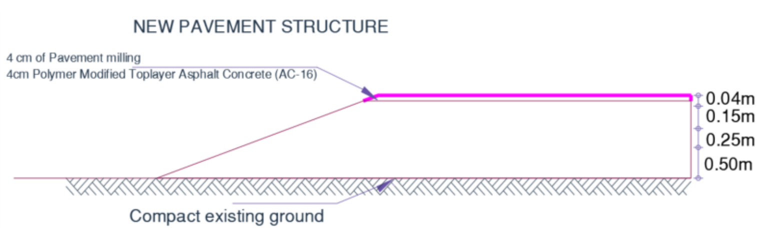
Figure 21. Pavement Structure 2



Source: Documentary information provided by the client.

Comprehensively, it was determined that secondary repairs were made to a 4-centimeter repaving, after scarification or milling of the existing asphalt binder.

Figure 22. Replacement of 4 cm of asphalt layer in secondary roads



Source: Documentary information provided by the client.

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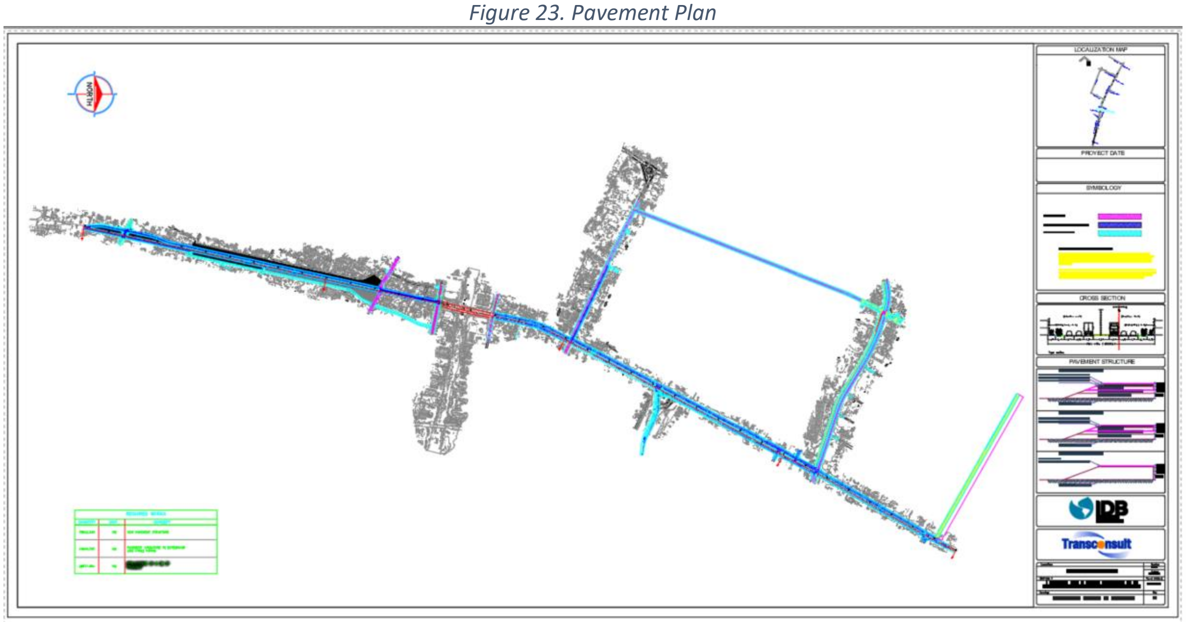
Figure 23 shows the plan in which the structures were drafted, in the SURI-PV-PTA file (attachments to this technical report).

Figure 23. Pavement Plan



Source: Transconsult

We recommend that for the final engineering design, the corresponding geotechnical studies are made for the design of the pavement structure.

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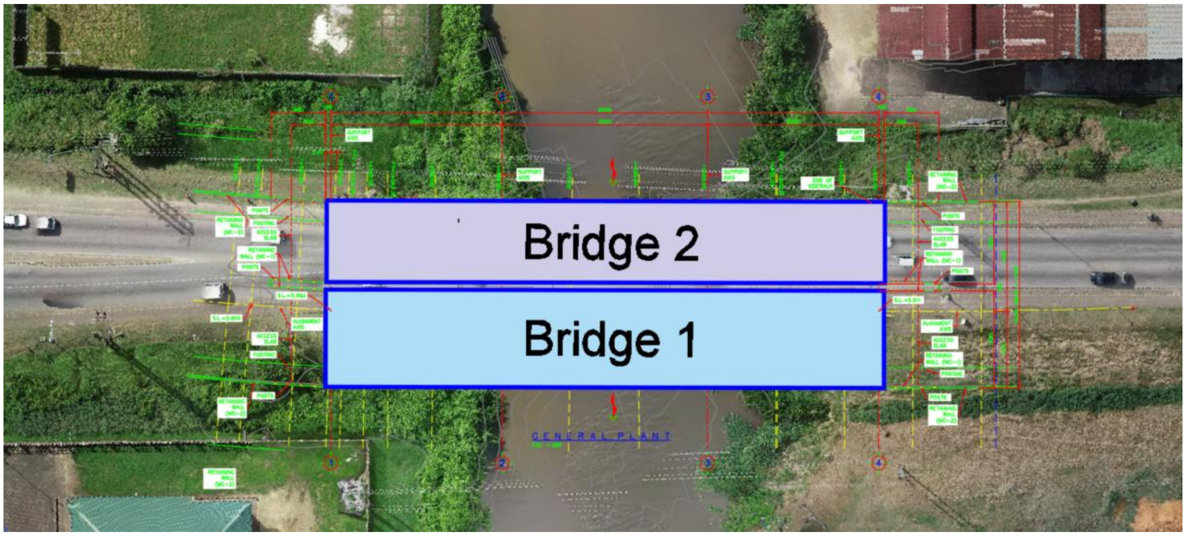
3.5 Major Works Preliminary Project (vehicular bridge).

Since the current bridge (Saramaccadoorsteek) cannot aloe heavy vehicles, it was decided to replace the bridge with one with a greater load capacity and enough crossing section to satisfy the projected traffic flows.

The bridge will be formed by two bodies or 2 bridges, the right body (bridge 1) for the vehicular flow from north to south and the left body (bridge 2) for the flow from south to north.

In the first stage, bridge 1 will be built allowing the current bridge to continue operating, the second stage will start when the right body is finished; the flow will be opened on this bridge and the currently existing bridge will be demolished to build the left body afterwards.

Figure 24. Proposed Bridge



Source: Transconsult

For the bridge design, the level of extraordinary maximum waters was determined considering a 100-year return period ruled mainly by topography and sea level taking in account maximum and minimum high tides levels.

For the crossing of floating debris (trash, trunks, branches, etc.) a free height measured from the extraordinary maximum water level to the lower bed of the 2.50 meters bridge structure is considered.

Taking in account the mentioned above, the bridge will have a height of 6.5 mts over the average sea level in the crest of the bridge.

3.5.1 Structural preliminary project of the bridge

The structural proposal of both bridges was made at the preliminary level:

The bridge was distributed in three sections with lengths to piles of 25.00m each (2) and one of 30m, with a total span of 80 m.

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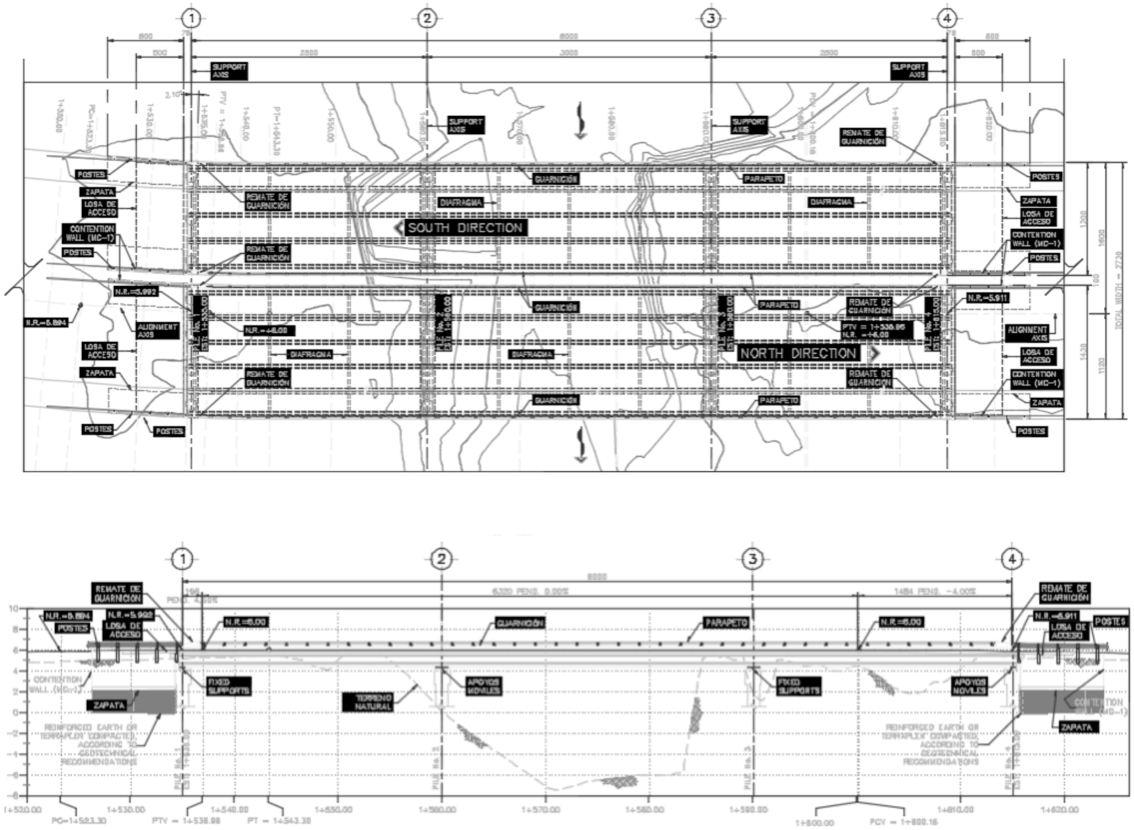
Figure 25. Geometry: Dimensions of the general plant and elevation by axis of the bridge.

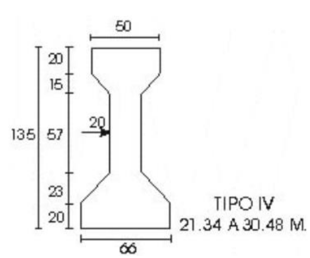


Source: Transconsult

The structure comprises the following elements:

- **Superstructure (boards and beams);** made with prestressed concrete in AASTHO section type IV; beams for 21.34m to 30.48m clearings (support areas at 30cm of head) and reinforced concrete slab on boards with a thickness of 20cm.

Figure 26. 3D dimensions of structural model, typical board (geometric idealization of the superstructure)



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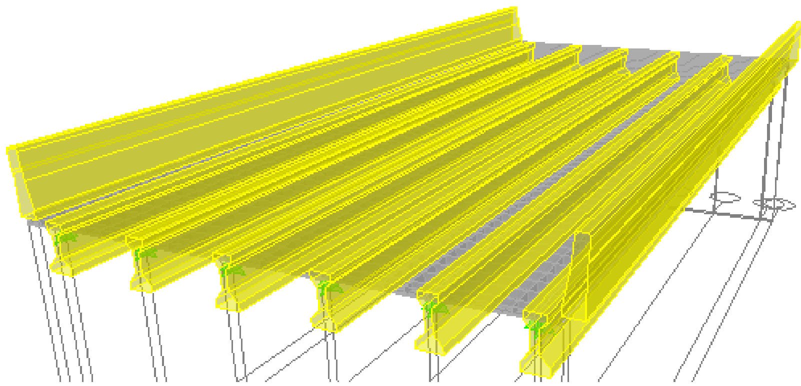
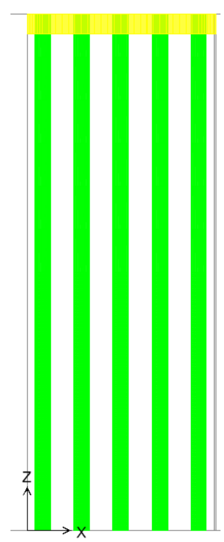


Source: Transconsult

- **Substructure (stacks and brackets);** reinforced concrete in heads, and foundation stacks. The stacks are of circular section, heads of rectangular section.

Figure 27. Stack Elevation



Source: Transconsult

3.5.2 Properties of the materials

Next items describe materials considered in the bridge pre-design

- Concrete

  a) Concrete with compressive strength f'c = 350 kg/cm^2, structural class 1; with fresh volumetric weight greater than 2.2 Ton/m^3. Maximum size of aggregate 13mm, Portland type cement in prestressed beams.

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b) Concrete with compressive strength f'c = 350 kg/cm^2, structural class 1; with fresh volumetric weight greater than 2.2 Ton/m^3. Maximum size of aggregate 13mm, Portland cement in slab, columns, heads, walls, pads and stacks.

- Reinforcing Steel

c) ASTM A-615 reinforcing steel, with yield strength fy = 4,200 kg/cm^2 for #3 rebar and larger.

- Prestressing Steel

d) Naked strands, braided with 6 wires, 0.5 in diameter; ASTM A-416, with I.r. > 19,000 kg/cm^2, 3.5% elongation and breaking strength of 20,000kg.

3.5.3 Standards and specifications

In the revision, the structures will be subject to the guidelines specified in the structural design codes in its latest edition:

- American Association of Highway and Transportation Officials “AASTHO”, LRFD Bridge design specifications 8th edition 2017.
- American Concrete Institute “ACI 318SUS-14”
- Manual for the Design of Prefabricated Structures “ANIPPAC” (Asociación Nacional de Industriales del Presfuerzo y la Prefabricación A. C.), Engineering Institute, UNAM.

3.5.4 Loads analysis

For bridge design and to provide the required security in each of its structural elements, two categories of actions were considered: "permanent actions and variable actions”:

- Permanent Actions

Dead loads produced continuously on the structure and whose intensity varies little in time. The main actions in this category are: the dead load (weights of all the constructive elements, of the finishes and of all the elements that occupy a permanent position and whose weight does not change substantially with time).

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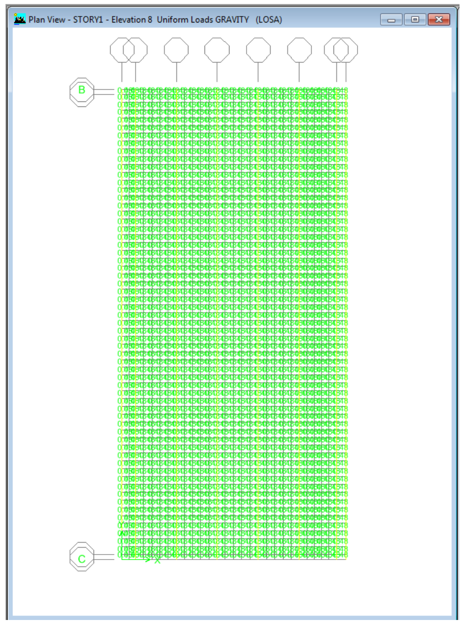
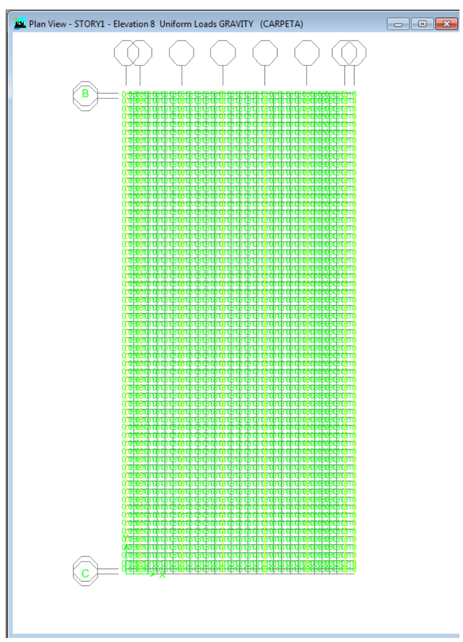
Figure 28. Plant: weight of slab distributed on board



Source: Transconsult

Figure 29. Plant: weight of layer distributed on board



Source: Transconsult

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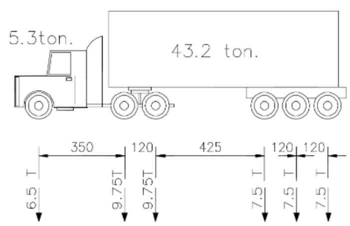
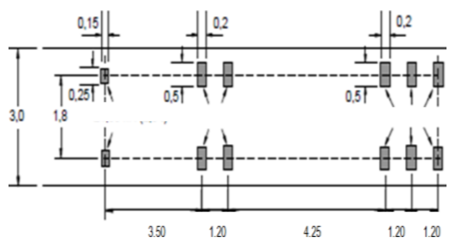
The evaluation of these loads was made considering the weights of the structural elements (own weight), of the materials that will be supported on the main elements, such as slabs of boards, asphalt layer, diaphragms, linings and parapets.

- Variable Actions

For this category the live load (design vehicle), temperature effects, imposed deformations and differential subsidence were considered; for the latter, expert criteria were used due to the lack of studies.

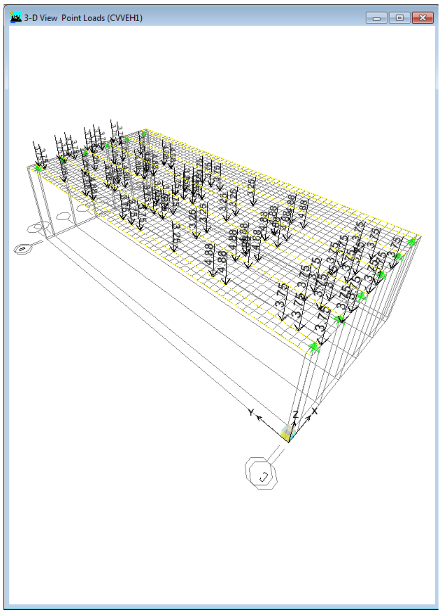
Figure 30. T3-S3 Design Vehicle (48.5 Ton)





Source: Transconsult

Figure 31. Vehicle load applied in three lanes (loaded towards the left shoulder)



Source: Transconsult

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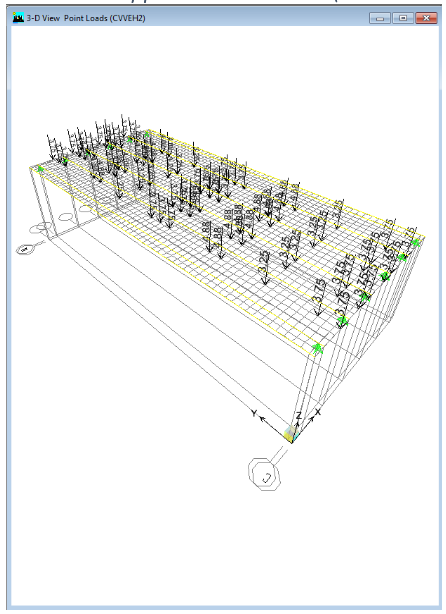
Figure 32. Vehicle load applied in three lanes (loaded to right shoulder)



Source: Transconsult

3.5.5 Seismic analysis

Due to the lack of a regional regulation for seismic analysis and design, the reference was made to the "Regulation for the seismic analysis and design of structures" from the Dominican Republic, due to its proximity to the area of interest and similarity regarding its geological and geotechnical characteristics.

Figure 33. Reference regulation corresponding to the Dominican Republic, with qualities and characteristics similar to the project area (coastline)

Source: "Regulation for the seismic analysis and design of structures" from the Dominican Republic

Below is a map with the seismic zoning to be considered, as well as the classification and properties of the subsoil for the site of interest.

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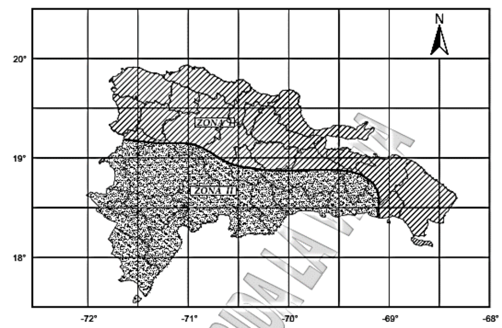
Figure 34. Soil consisting of surface sands and fractured basalt rock.

MAPA N°1. - ZONIFICACIÓN SÍSMICA



Artículo 9. De acuerdo a la zonificación sísmica establecida en el Artículo 8, los valores de la aceleración espectral de referencia para períodos cortos (S_S) y para períodos largos (S_1) serán los indicados en la tabla siguiente:

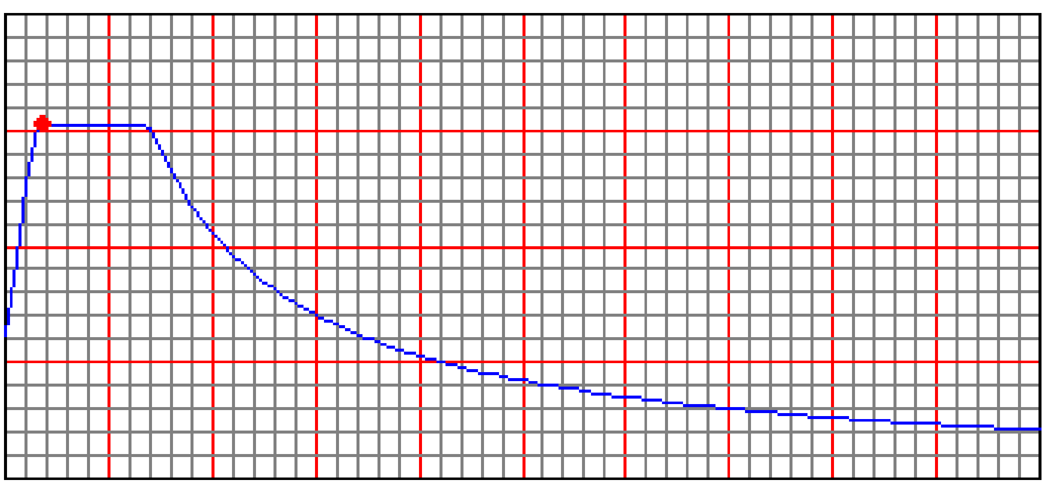
TABLA 1
ZONIFICACIÓN SÍSMICA. VALORES DE S_S y S_1

ZONA	S_S	S_1
I	1.55 g	0.75 g
II	0.95 g	0.55 g

Source: "Regulation for the seismic analysis and design of structures" from the Dominican Republic

Once the seismic parameters of the site of interest have been estimated, it is possible to construct a seismic design specter as shown in the following graph, which will help us to better determine the behavior of the structure before a seismic event.

Figure 35. Seismic Coefficient c = 0.24435g for a Te = 2.554 seg structure period. Modified specter (Factorized 1.5 times)



Source: Transconsult

Figure 36. Seismic Coefficient c = 0.24435g for a Te = 2.554 seg. structure period Modified specter (Factorized 1.5 times)

Table 2 shows the tabulated values used to construct the seismic specter shown in the previous graph.

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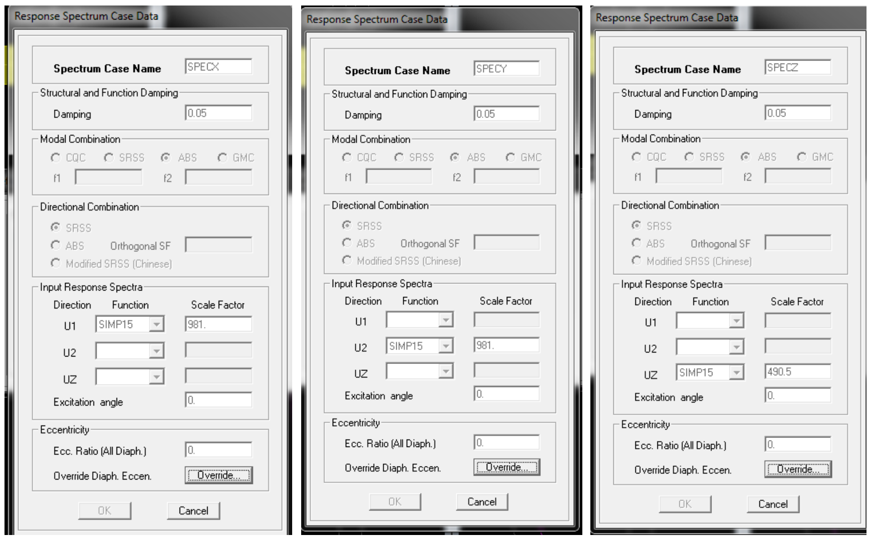
Table 2. Values for construction of the seismic specter.

T	a
seg	g
0	0.0978
0.04	0.15075
0.08	0.2037
0.12	0.24435
0.16	0.24435
0.2	0.24435
0.24	0.24435
0.28	0.24435
0.32	0.24435
0.36	0.24435
0.4	0.24435
0.44	0.24435
0.48	0.24435
0.52	0.24435
0.56	0.2415
0.6	0.22545
0.64	0.21135
0.68	0.1989
0.72	0.18795
0.76	0.17805
0.8	0.16905
0.84	0.1611
0.88	0.15375
0.92	0.147
0.96	0.14085
1	0.1353
1.04	0.13005
1.08	0.12525
1.12	0.12075
1.16	0.11655
1.2	0.1128
1.24	0.10905
1.28	0.10575
1.32	0.10245
1.36	0.09945
1.4	0.0966
1.44	0.0939
1.48	0.09135
1.52	0.08895
1.56	0.0867
1.6	0.0846
1.64	0.0825
1.68	0.08055
1.72	0.0786
1.76	0.0768
1.8	0.07515
1.84	0.0735
1.88	0.072
1.92	0.0705
1.96	0.069
2	0.06765
2.04	0.0663
2.08	0.0651
2.12	0.06375
2.16	0.0627
2.2	0.0615
2.24	0.06045
2.28	0.0594
2.32	0.05835
2.36	0.0573
2.4	0.0564
2.44	0.0555
2.48	0.0546
2.52	0.0537
2.56	0.0528
2.6	0.05205
2.64	0.0513
2.68	0.0504
2.72	0.0498
2.76	0.04905
2.8	0.0483
2.84	0.0477
2.88	0.04695
2.92	0.04635
2.96	0.04575
3	0.04515
3.04	0.04455
3.08	0.04395
3.12	0.04335
3.16	0.04275
3.2	0.0423
3.24	0.0417
3.28	0.04125
3.32	0.0408
3.36	0.0402
3.4	0.03975
3.44	0.0393
3.48	0.03885
3.52	0.0384
3.56	0.03795
3.6	0.03765
3.64	0.0372
3.68	0.03675
3.72	0.0363
3.76	0.036
3.8	0.03555
3.84	0.03525
3.88	0.0348
3.92	0.0345
3.96	0.0342
4	0.03375

Source: Transconsult

Once the seismic design specter is determined, it is loaded into the structural analysis software to be allocated as an accidental load to the structure in its three orthogonal directions (X, Y, Z), as shown in the following image.

Figure 37. Seismic specter of the structure model.

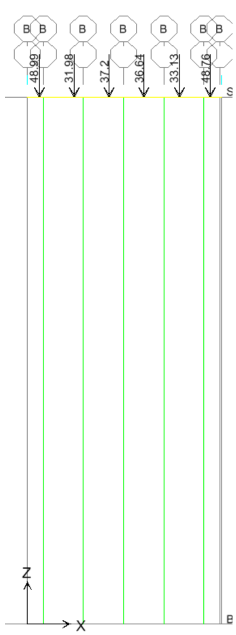


Source: Transconsult

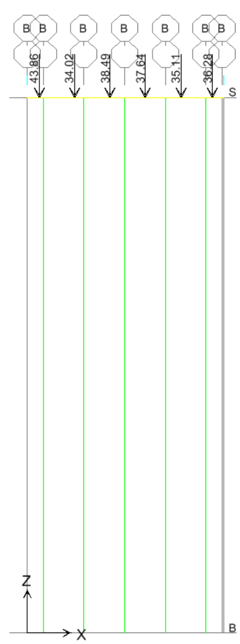
Due to the permanent and variable actions that work on the slab of the bridge there are discharges that are sent to the head at the points where the beams are supported, said discharges are shown below in the following images.

- Superstructure Discharge

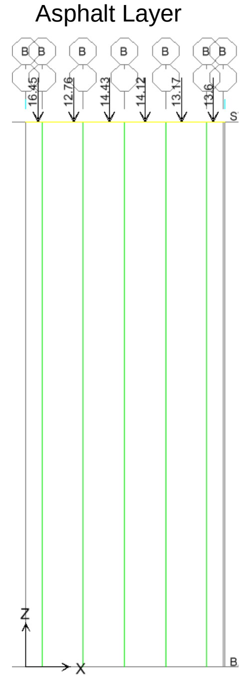
Own Weight



Slab and Overload



Asphalt Layer



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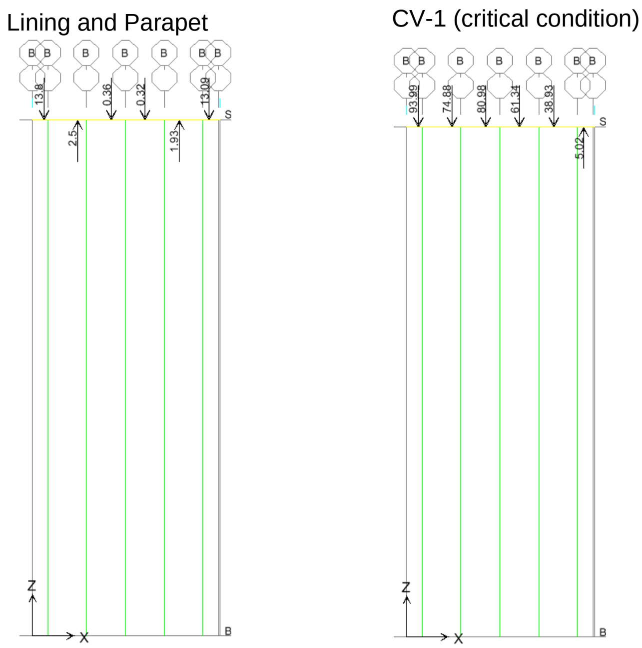
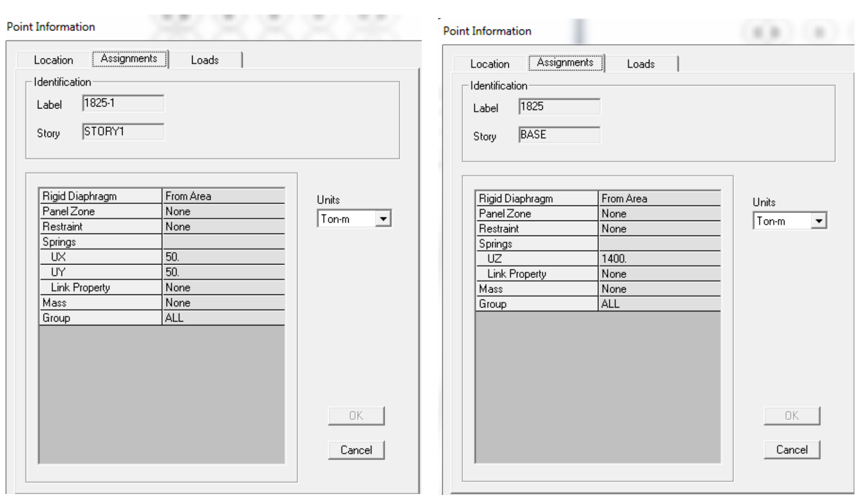


- Reaction Modules

The behavior of the structure can be simulated in an approximate way due to the elastic properties of the soil. These values are obtained from the soil mechanics study or, if there is no previous study, it will be valid to take into account the recommendations stipulated in the corresponding design code.

The reaction modules used and loaded to the mathematical model of the pin structure are horizontal reaction module of 50Ton/m (500 kg/cm) and vertical reaction modules of 1,400Ton/m (14,000 kg/cm) are shown below).

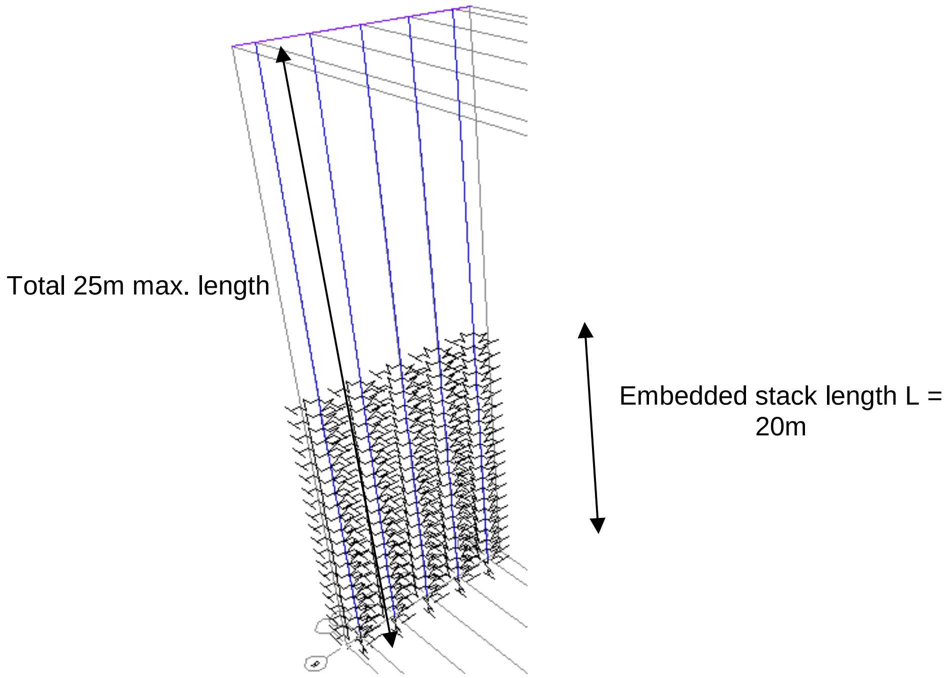
Figure 38. Elastic springs for load capacity per 70 Ton tip and supported by altered rock.



Source: Transconsult

It was considered a stack embedment length of 20.00m below the level of the natural terrain, in sands with a saturated density of γ_{sat} = 2.86 Ton/m^3.

Figure 39. Embedment Length

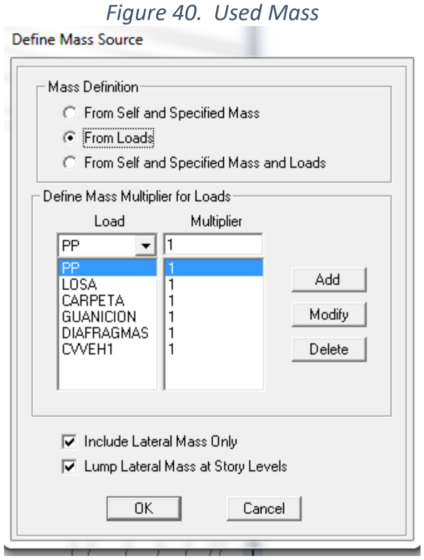


Source: Transconsult

- Mass

Finally, within the analysis program, the mass source is defined so that the internal seismic force acting on the structure can be determined internally.

Figure 40. Used Mass



Source: Transconsult

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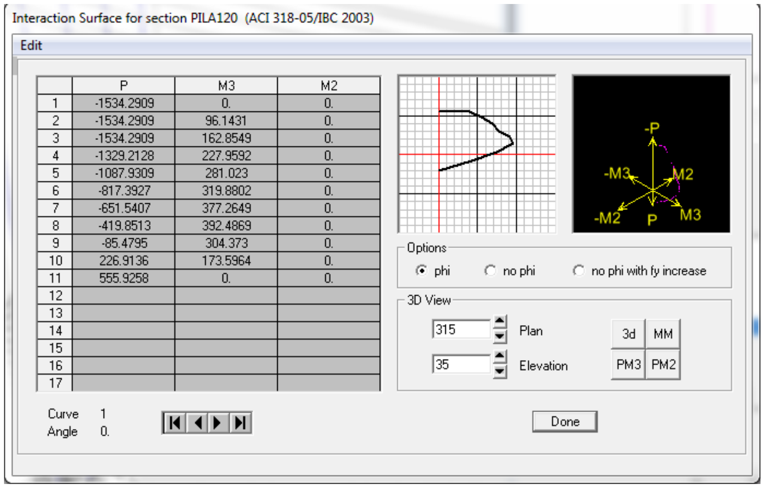
- Structural design of main elements

Once all the parameters of the structure have been defined within the software, the structural analysis is performed to obtain mechanical elements and perform afterwards the design of each important structure element as shown in the following images.

Figure 41. Stacks interaction curve



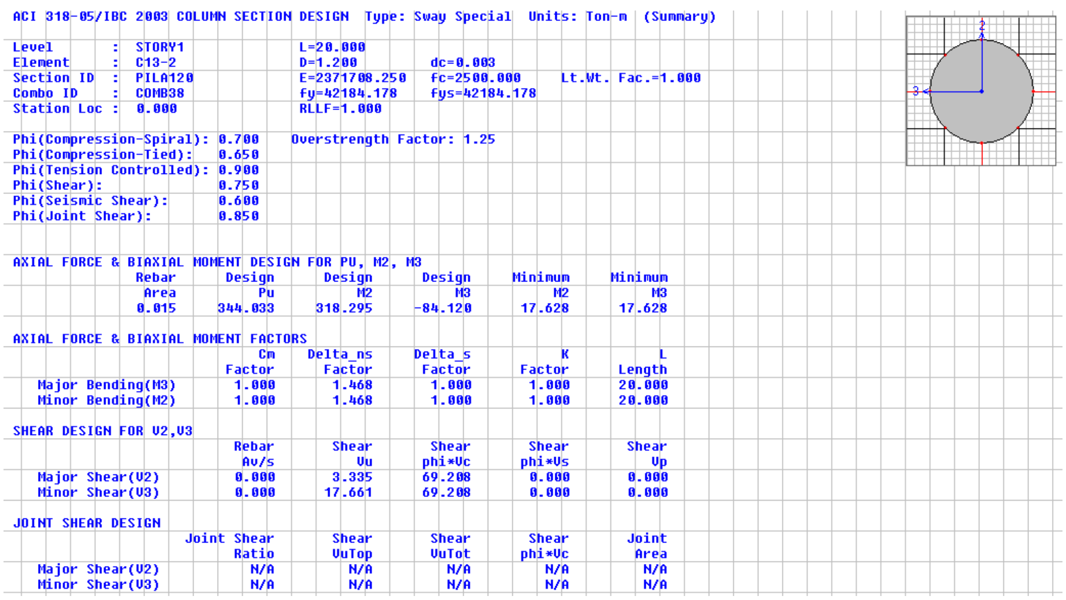
Interaction Surface for section PILA120 (ACI 318-05/IBC 2003)

Edit

	P	M3	M2
1	-1534.2909	0.	0.
2	-1534.2909	96.1431	0.
3	-1534.2909	162.8549	0.
4	-1329.2128	227.9592	0.
5	-1087.9309	281.023	0.
6	-817.3927	319.8802	0.
7	-651.5407	377.2649	0.
8	-419.8513	392.4869	0.
9	-85.4795	304.373	0.
10	226.9136	173.5964	0.
11	555.9258	0.	0.
12			
13			
14			
15			
16			
17			

Source: Transconsult

Figure 42. Stacks design



ACI 318-05/IBC 2003 COLUMN SECTION DESIGN Type: Sway Special Units: Ton-m (Summary)

Level : STORY1 L=20.000
Element : C13-2 D=1.200 dc=0.003
Section ID : PILA120 E=2371708.250 fc=2500.000 Lt.Wt. Fac.=1.000
Combo ID : COMB38 fy=42184.178 fys=42184.178
Station Loc : 0.000 RLLF=1.000

Phi(Compression-Spiral): 0.700 Overstrength Factor: 1.25
Phi(Compression-Tied): 0.650
Phi(Tension Controlled): 0.900
Phi(Shear): 0.750
Phi(Seismic Shear): 0.600
Phi(Joint Shear): 0.850

AXIAL FORCE & BIAXIAL MOMENT DESIGN FOR PU, M2, M3

Rebar Area	Design Pu	Design M2	Design M3	Minimum M2	Minimum M3
0.015	344.033	318.295	-84.120	17.628	17.628

AXIAL FORCE & BIAXIAL MOMENT FACTORS

	Cm Factor	Delta_ns Factor	Delta_s Factor	K Factor	L Length
Major Bending(M3)	1.000	1.468	1.000	1.000	20.000
Minor Bending(M2)	1.000	1.468	1.000	1.000	20.000

SHEAR DESIGN FOR V2,V3

	Rebar Av/s	Shear Vu	Shear phi*Vc	Shear phi*Vs	Shear Vp
Major Shear(V2)	0.000	3.335	69.208	0.000	0.000
Minor Shear(V3)	0.000	17.661	69.208	0.000	0.000

JOINT SHEAR DESIGN

	Joint Shear Ratio	Shear VuTop	Shear VuTot	Shear phi*Vc	Joint Area
Major Shear(V2)	N/A	N/A	N/A	N/A	N/A
Minor Shear(V3)	N/A	N/A	N/A	N/A	N/A

Source: Transconsult

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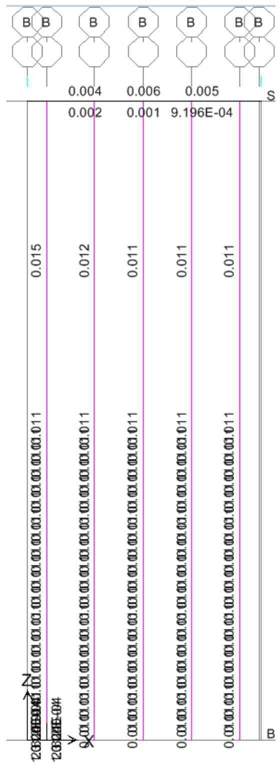
Figure 43. Steel amounts in stacks and head



Source: Transconsult

- Foundation stacks with a 120cm diameter section; ϕ = 1.5% (As = 169.65cm^2); 34 # 8 rods, to maintain symmetry, 39 rods are kept.

- Head with 200cmx150cm section; ρ_{min} = 0.00301 (Asmin = 87.94cm^2); 18 # 8 rods (both beds); 36 total, will be placed vaults of # 8 to cover the remaining amount (0.005) = 59.06cm^2 (12 additional rods)

For more details see attached drawings of bridge sizing in the annex appended to this document (SURI_SNPB-01).

For the final design of the bridge, it is recommended to carry out the final design based on the soil mechanics, hydrology, wind studies and all studies that could affect its design.

3.6 Road Signaling

The proposal includes the pre-design of horizontal and vertical signs based on the Vienna Convention on Road Signs and the ASTM D-4956 standard, due to the lack of national regulations.

The horizontal signaling consists of: lane divider lines, directional arrows at intersections, horizontal marking at safe crossings (high lines, pedestrian crossing lines) and delimiting elements for bikeways (boundary markers).

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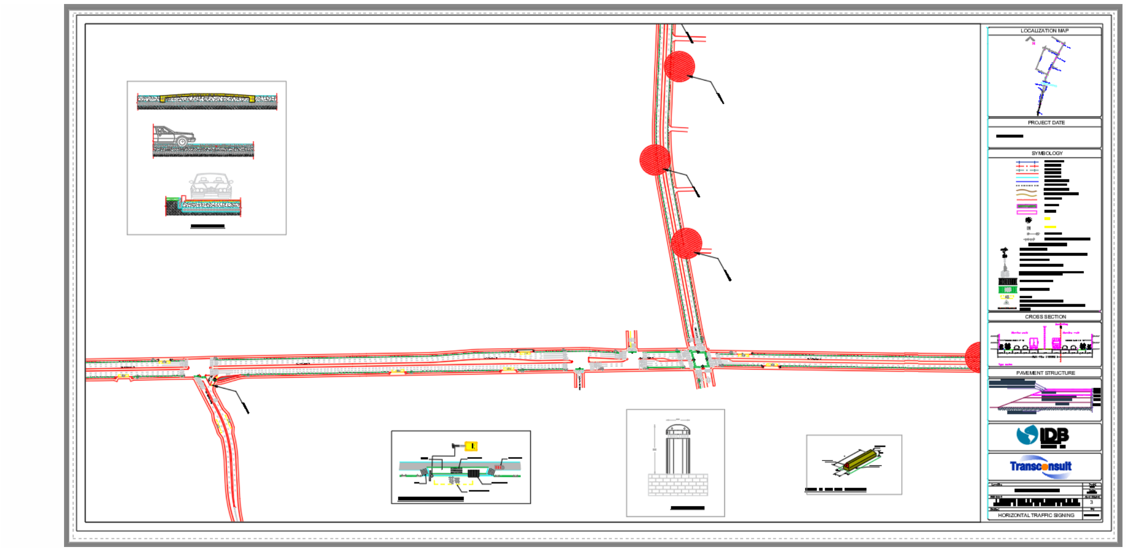
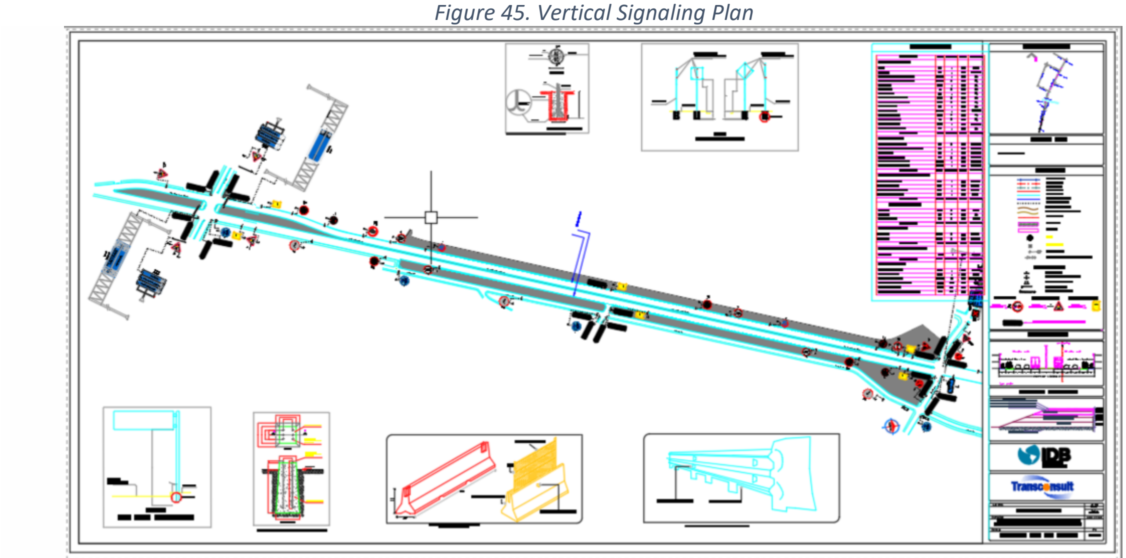
Figure 44. Horizontal Signaling Plan



Source: Transconsult, see 5.0 Traffic signals plan (appended to this documents)

The vertical signaling was made through the comprehensive location of vertical signals, which fully serve private vehicles, cargo vehicles, public transport vehicles, bikeways and pedestrians, based on international regulations for the circulation of vehicles that drive on the left. These signals were selected and placed at strategic points according to the road speed, as set in international recommendations.

Figure 45. Vertical Signaling Plan



Source: Transconsult, see 5.0 Traffic signals plan (appended to this document)

3.7 Complementary Sewerage and Induced Works Preliminary Project

To cover all engineering aspects possible in the improvement of roads, a proposal of 1 km of pre-design was made to address the minor sewerage s and induced works that the road should have. In the appendix, the plans that correspond to each public utility are added.

- Storm Sewer Preliminary Project
- Sanitary Sewerage Preliminary Project
- Street lighting Preliminary Project
- Drinking Water Preliminary Project

3.7.1 Design criteria

To determine the hydraulic area, continuity formulas were used in which it is established that the hydraulic volume or flow rate depends on the flow velocity through the hydraulic area.

The hydraulic area is obtained directly from the planes, profiles and sections obtained for the axle box of the parallel channels, the speed was considered to be 1.0 m/s, the most appropriate occurring in channels in natural soil with friction coefficients between 0.013 and 0.017 dimensionless.

The concrete elements were designed for marine environments and premixed sulphates with a f'c = 250 kg/cm^2 strength or higher.

In quantification, the design considers dismounting 30 cm thick of vegetal layer and excavation in type A-B-C material (80-20-00)

The characteristics of the earthworks and pavements were designed to be moved on sandy soils with low surface water beds, characteristics observed in sites with similar topographical and geographical characteristics. This criterion was also applied to the design of pavements. For final design, geotechnical studies must be carried out to determine the structure.

To obtain the useful life of the main corridor pavement design, it was considered to protect it from rainwater and runoff. Therefore, works that quickly evacuate the rainwater on the road and at high points were proposed, avoiding erosions or waterlogging.

The existing rainwater runoff will continue to protect the corridor with road protection works and the crossings, with storm sewers. The design contemplates that the runoff in roadways is done by gravity with catchment works (pluvial grids) in the low points according to the pumping of the road.

The wastewater collection system is designed as a combined system (black and gray water in the same system), formed by 30 to 60 cm diameter collectors. The 30 to 60cm diameter PVC pipe sanitary network will collect the water from each lot and will lead it to the pumping stations and in turn these will re-pump it to the treatment plant.

The drinking water and household connections distribution network was designed with the existing diameters and hydraulic capacities and relocating it according to the roads design. This contemplates PVC with diameters indicated in drawings. The network was placed under the sidewalk of the road section. The special pieces of cruisers and operating boxes of cast iron valves were placed under the pavements. To resist piezometric loads, at intersections or where sectioning valves are installed, red and annealed concrete wall operating boxes

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with springs and empty iron covers with a sign indicating the type of service (drinking water) were drafted.

The material considered for this predesign resists at least 100 m.c.a.

3.7.2 Pluvial protection works

- Parallel channels.

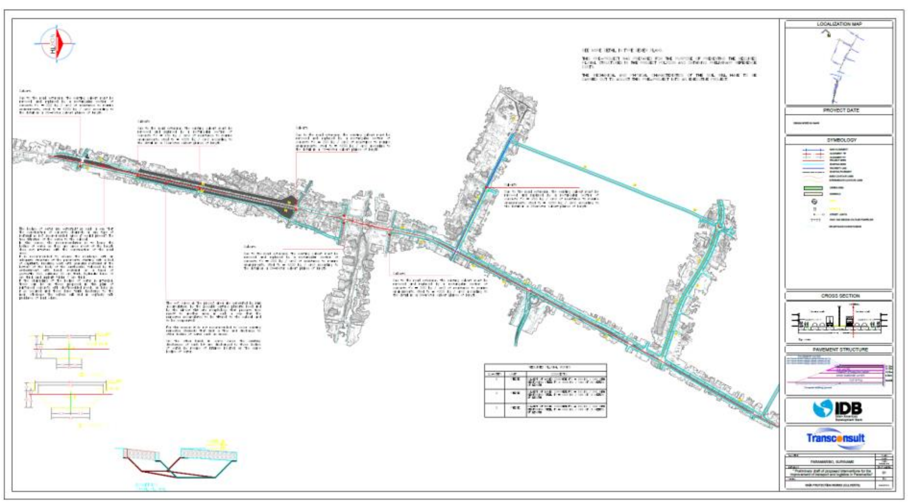
The channels parallel to the road axes do not interfere with the construction of the additional lane so they can remain in the current state; however, it will be necessary to consider a pavement structure suitable for the type of ground and contact with surface water beds as the one on the site.

- Box culverts.

Based on the topography obtained from the drone flight, the culverts were placed on plans that should complement the expansion project. In the plans, the sewers or bridges culverts to dislodge the rainwater are indicated at the pre-design level. Three types of square sewers were proposed, which will be reinforced concrete with 1.4 X 2.0 meters dimension at the entrance and exit varying the length of culverts at 26, 16 and 12m.

For its construction, final design must be carried out according to the relevant studies required for its execution.

Figure 46. 1 km Pluvial Sewer Preliminary Project

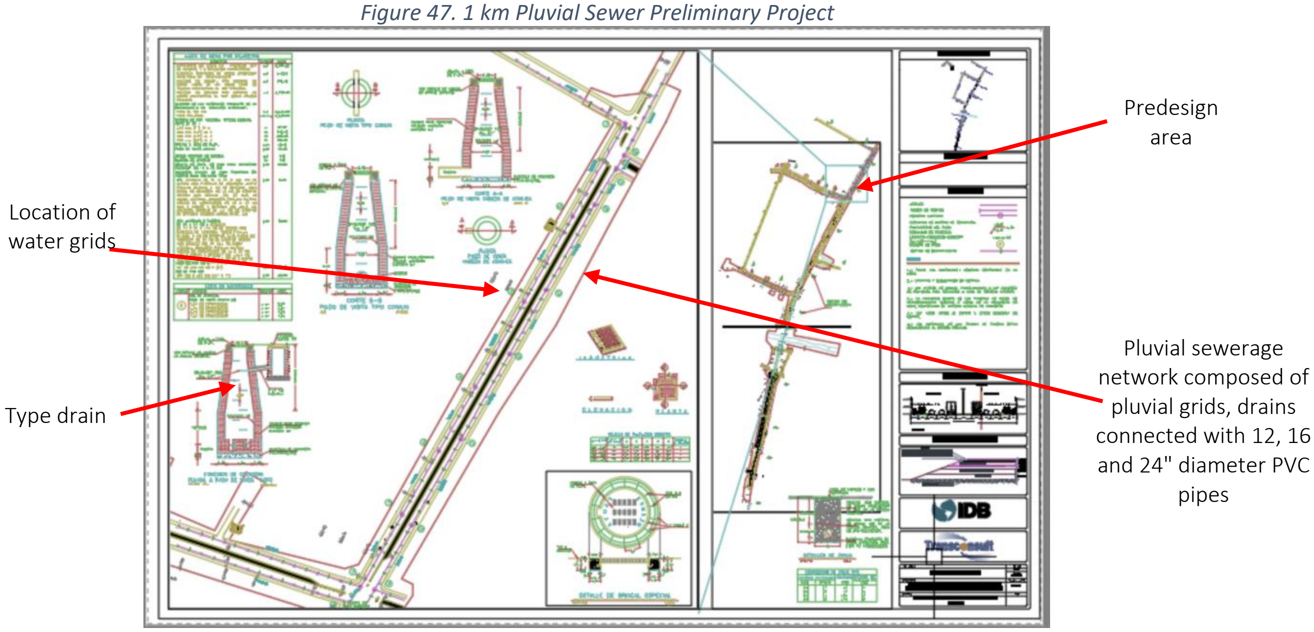


Source: Transconsult (See 9.0 Culvert plan (Appended to this document)

3.7.3 Hydro sanitary services

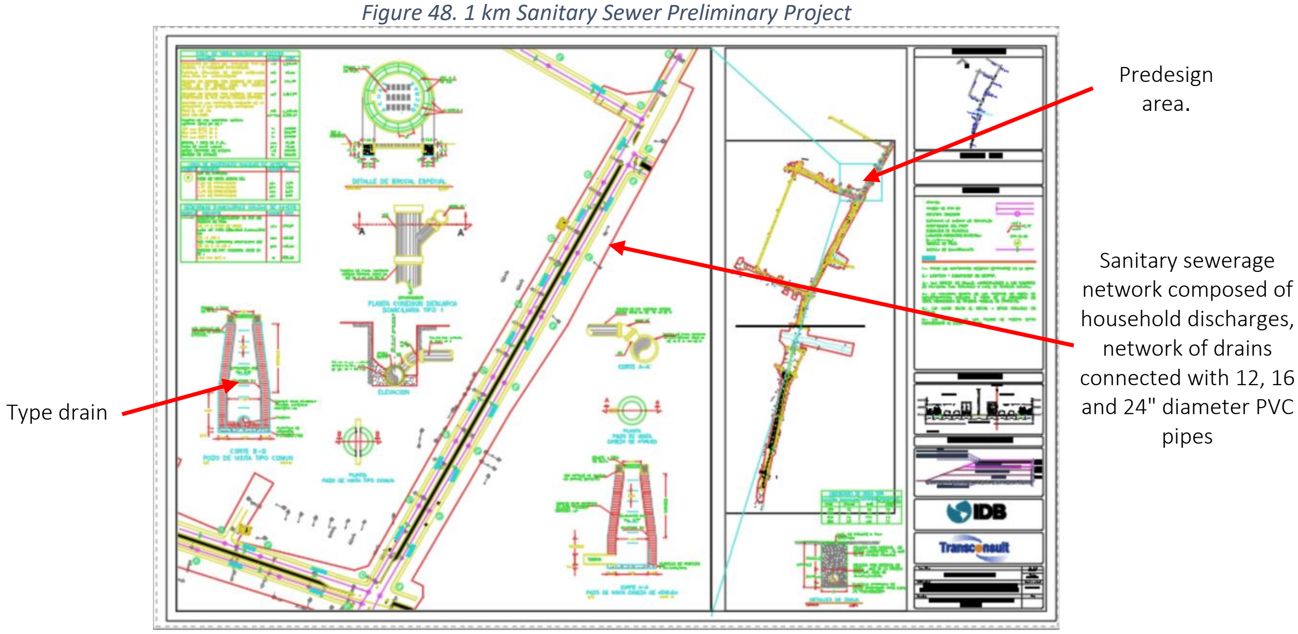
Due to the lack of detailed information on the current sewerage, the pre-design of 1 km of sanitary and storm sewerage was generated. This pre-design contemplates a network of drains connected by 12, 16 and 24" diameter PVC pipes, considering special pieces, type curbs in drains, pluvial grids and connection details between the sewerage network and household discharges.

Figure 47. 1 km Pluvial Sewer Preliminary Project



Source: Transconsult, see 6.0 Sewered pluvial plans (Appended to this document)

Figure 48. 1 km Sanitary Sewer Preliminary Project



Source: Transconsult, see 7.0 Sewered sanitary plans (Appended to this document).

This proposal should be complemented in the final design through the relevant studies throughout the entire project.

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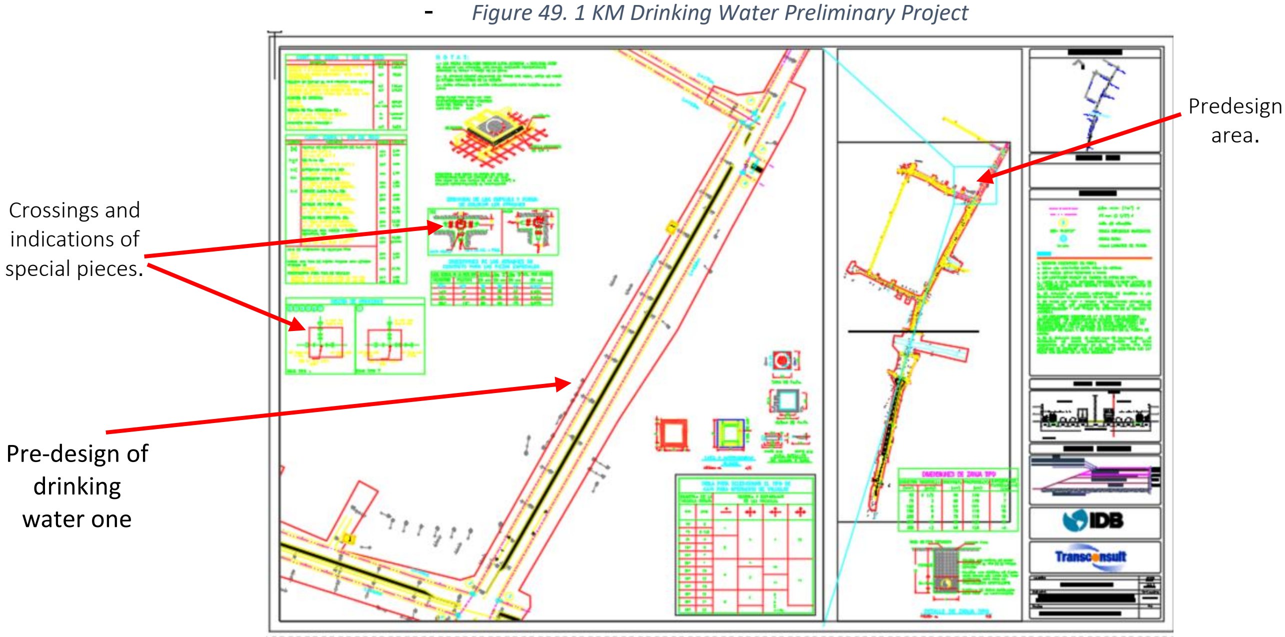
3.7.4 Drinking water

For this item, the information provided by the ministries of Surinam was analyzed, identifying a drinking water network with 50, 100 and 150-mm diameter.

With the previous analysis, a proposal of 1 km of pre-design was generated to protect and adapt the current drinking water system, ordering the service along the road through elements such as:

- Drinking water crossings
- Cast iron sectioning valves
- Installation of 2 and 10" diameter PVC pipes
- Generic proposal of the trench where the pipeline will be installed and protected.

- *Figure 49. 1 KM Drinking Water Preliminary Project*



Source: Transconsult, see 8.0 Drinking water plans (Appended to this document)

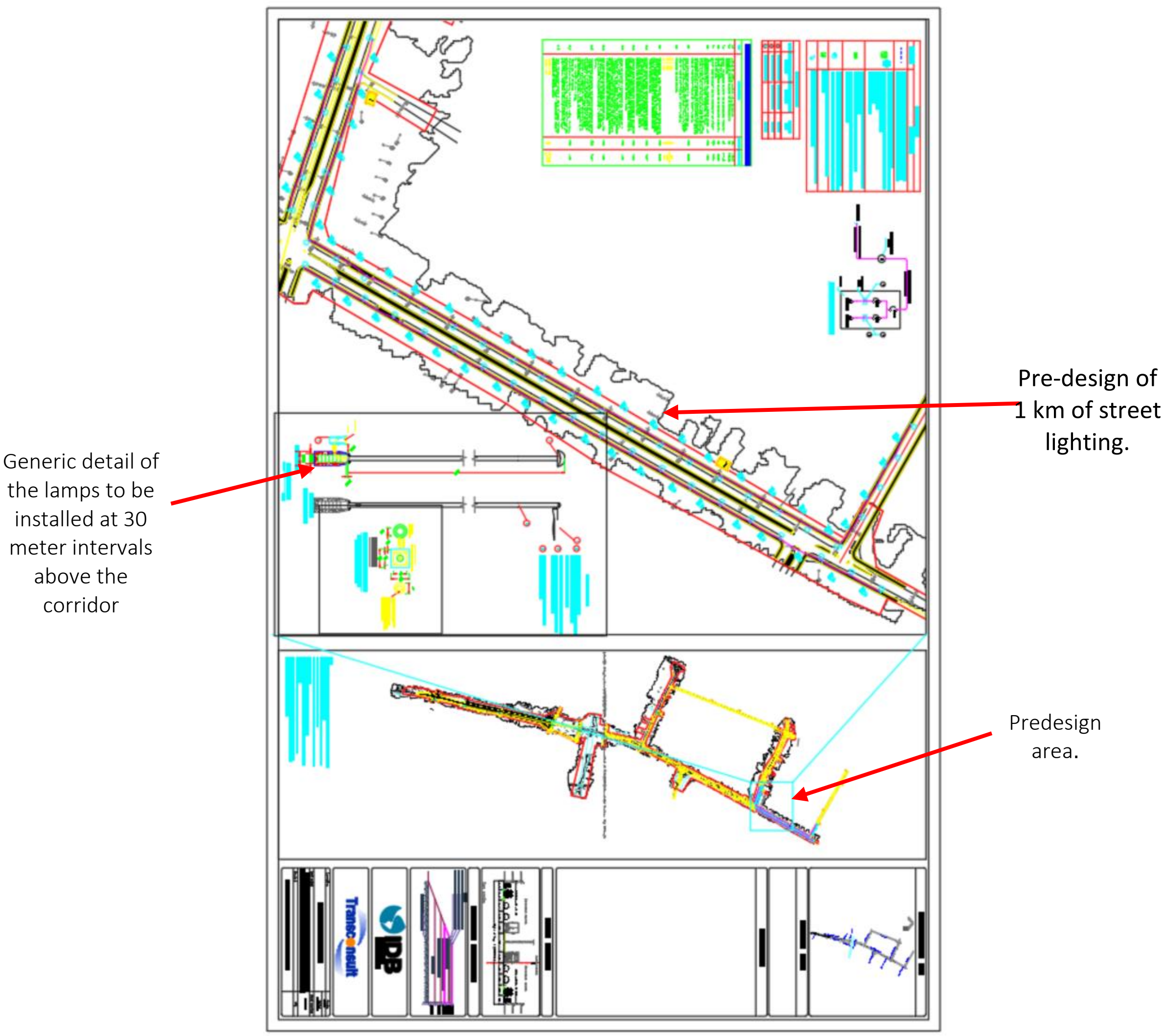
The final design must contemplate the connection to infrastructure connection points and discharge points.

3.8 Street lighting

For the pre-design of street lighting, the Orthomosaic generated by the drone flight was analyzed; in the orthophoto, existing poles and lamps were located on the study area.

With data obtained, a proposal of 1 KM of pre-design was made. The proposal consists of removing the existing lighting elements that will not be shareable due to the extension of the corridor. Thus, the proposal includes the installation of new lighting infrastructure, the use of poles and lamps every 30 meters complemented by concrete boxes in street crossings. (See 10.0 Street lighting plans, appended to this document).

Figure 50. 1 KM Street lighting Preliminary Project



Source: Transconsult, see 10.0 Street lighting plan (appended to this document)

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3.9 Estimation of Capex

To obtain the costs of each item, a market research was carried out online and through documentary information, making some quotations on construction materials in Suriname.

From the quotes it was identified that the factor to be considered is the price of the materials to produce concrete and its transportation; because apparently there are limitations in the local supply chain.

The summary table of the integral cost of each element for the improvement of transport and logistics in Paramaribo is shown below.

Table 2. Summary table of the base cost of the interventions.

Concept	Amount (USD)	
Road Work		
Preliminary and final works	$	2,692,800.57
Signage for protection of work	$	258,372.90
Divert way	$	600,600.00
Construction of sidewalks and kerbstone	$	4,076,103.84
Road	$	9,213,768.43
SUBTOTAL	$	16,841,645.74
Public services		
Culverts	$	596,073.74
Storm drain	$	1,305,391.30
Street lighting	$	337,598.73
Horizontal and vertical signage	$	516,745.80
Supply and installation of traffic lights including with control systems and wiring for 4 phases.	$	1,560,856.29
Optical fiber	$	629,296.73
Sanitary drainage	$	802,544.92
Drinking water project	$	379,795.30
SUBTOTAL	$	6,128,302.81
Construction of vehicular bridge		
Bridge	$	8,956,906.42
Demolition of the existing bridge		$563,821.19
SUBTOTAL	$	9,520,727.61
Public space and final engineering design		
Woonerf	$	874,969.61
Park and Wetland		$443,728.45
Final engineering project		$2,350,384.31
SUBTOTAL	$	3,669,082.37
TOTAL		**$36,159,758.54**

Source: Transconsult

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4. Climate Change

The pluvial and sanitary drainage is designed for 10 years; however, due to climate change it was considered to increase the design to 20 years. For this a parametric evolution was performed adjusting 30.45, 63 diameters to 40, 63, and 120 cm. For this, an adjustment of 25% of the cost must be made on the draft.

Regarding the auxiliary drainage system in the road, the proposal considers the drains and sewers on the side of the road. This design was made focused on a 25-year return event. However, as it is a pre-design it is suggested to add 25% of the cost of the drainage works as the cost related to Climate Change, which will serve to adjust final design prior to execution of work for additional costs that are not identified in this stage.

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5. Recommendations

As mentioned in each item of this pre-design, it is recommended that final design, includes the next studies:

- Highly detailed topographical survey with total station.
- Identification of underground public utilities and its assessment.
- Connections and infrastructure connection points.
- Geotechnics and ground mechanics studies on the corridor and secondary roads. Indices properties of soils and pavements structure, stratigraphic levels, groundwater level and the data necessary for the final pavement design, the vehicular bridge, filling materials in roads, drainage, etc. will be determined.
- Extraction of core samples in the existing lanes
- Location of loan and draft banks; in loan banks, samples must be sampled to ensure that they are suitable for the entire work.
- Population census and growth factor according to the expected population.
- Hydrological study through the existing meteorological stations, determined watersheds and runoff direction, rainfall intensity, filtration, degree of evaporation of rain and all this complemented by the rivers, lakes, vegetation and rainwater study.

Detailed analysis of unit construction prices, including market study of construction materials, salaries, yields and machinery costs.

6. Conclusions

- The design will expand vehicular capacity of the main corridor (Martin Luther Kingweg-Van´t Hogerhuysstraat) that is used for 50,000 vehicles daily to reach Paramaribo downtown.
- Proposals are focused in build additional capacity (extra lanes) including upgrading the bridge over Saramaccadoorsteek that will allow heavy vehicles that will support traffic growths in future years. Pedestrian and bike users are also benefited with the construction of public infrastructure that will encourage non-motorized mobility.
- This pre-design was developed based on documentary information and topography profiling thru drone flights and terrestrial topographic support that provides a good approximation of natural terrain and pavement levels. For final design it is recommended to carry out direct topography with total station in the roads of analysis.
- A proposal of reconfiguration of underground public utilities was included in this pre-design based in the consultant experience since data provided does not have enough level of detail. Exact location of underground utilities must be a major task during final design and construction
- According with data provided by government, the proposed interventions does not affect private properties, however this must be confirmed during the execution of final design.

MÉXICO

Av. De la Alborada No. 124, Piso 3, Col. Parques del Pedregal,
14010, CDMX, México.
Tel: + 52 (55) 5927-5940 | www.transconsult.com