Royal HaskoningDHV
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REPORT

Cervejas De Moçambique Structural Roof Assessment

Client: Cervejas De Moçambique

Reference: KA1831-RHD-ZZ-XX-RP-Z-0001

Status: S0/P01.01

Date: 2/25/2021

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1 Introduction

1.1 Background

Cervejas De Moçambique, being in Beira, is frequently hit by tropical depressions, storms and cyclones. In March of 2018, Cyclone Idai caused significant damage to the infrastructure, especially to the roofs. In 2019, repairs were done on some roof structures, however the Cyclone Chalane in December 2020 highlighted severe waterproofing problems to the Packhall roof, with large amounts of water pouring into the building.

Concerned about the safety of the people and property, as well as the significant impact this may have on operations and food hygiene standards, Cervejas De Moçambique approached RHDHV to do an assessment of all the roof structures in the brewery, with special attention to Packhall, Un/Loading Bay and the Old Cellars, which are most critical.

1.2 Location

The subject of this assessment report, Cervejas De Moçambique, is located at Bairro da Manga in Beira, Mozambique (-19° 46' 1.6932", 34° 51' 43.833").

Figure 1: Location of CDM on the map

2 Scope of Work

The purpose of this consultancy service is to evaluate the roof conditions of all areas at CDM. A top view image of the brewery showing its layout and legend is presented in the figure below.

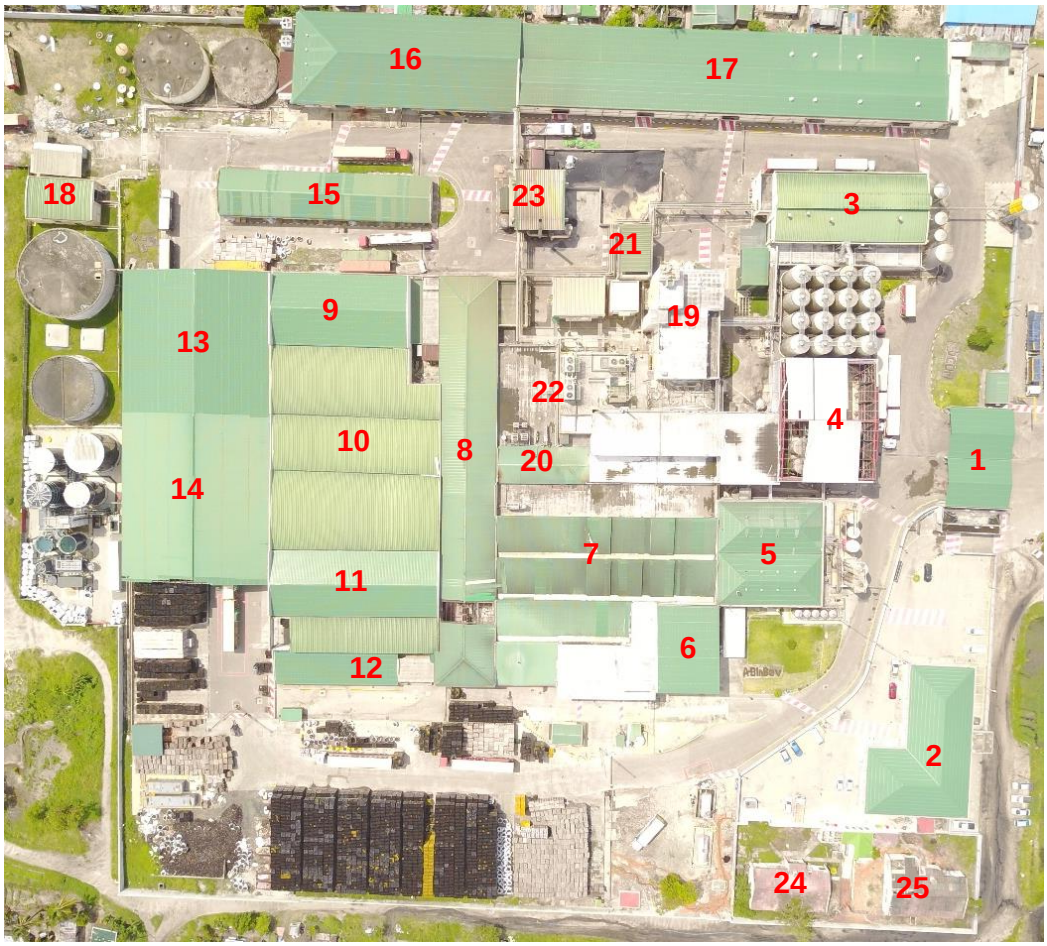


Figure 2: Layout of CDM

LEGEND

1 - Main Entrance
2 – Admin. Offices
3 – Brew House
4 – Old Cellars
5 – Canteen and Filtration
6 – Lab./Technical Build.
7 – Pack Hall
8 – Pack Hall
9 – Fulls Warehouse
10 – Finished Goods Warehouse
11 – Empty Botles Warehouse
12 – Logistics Meeting Room
13 – Un/Loading Bay - North
14 – Un/Loading Bay - South
15 – Change Rooms
16 – Old Chibuko House
17 – Raw M. Warehouse
18 – Water Treatment Plant
19 – Silos Building
20 – CO_2 Plant
21 – Malt Intake
22 – Engine Room
23 – Boilers
24 – Residence 1
25 – Residence 2

It was requested by CDM that special attention shall be paid to three buildings which were most affected by the cyclones: Old Cellars, Pack Hall and Un/Loading Bay.

The assessment shall include the following:

- Description of the current state of the roofs.
- Description of the anomalies identified.
- State of conservation of the roofs and its structural elements.
- General classification of the roofs for each building.
- Recommendations on how to proceed following the assessment.
- Method statement for the repair works while not disrupting operations (design not included).

The method statement is not included in this report. It will be a separate document to be delivered after the meeting with CDM to review the recommendations given in this report.

Although the scope of works was only to evaluate the roof structures, some buildings presented very noticeable damage on the walls, columns and slabs. A general, high level, evaluation and recommendation will also be given as part of this assessment given the fact that some of elements are in critical condition presenting a great danger to the people using the facilities.

3 Methodology

To properly evaluate the roof structures of CDM, a team from Royal HaskoningDHV travelled to Beira for a kick-off meeting with CDM and a 2-day guided site visit through the whole brewery.

The kick-off meeting was vital to understand the concerns of CDM regarding the condition of the buildings and what they expected from this inspection.

A representative of CDM guided the RHDHV team composed of a structural engineer and a mechanical engineer while visiting all buildings (except the residences which are not being used due to their degrading state) and inspected the roofs from the inside of each building and from the outside. The inspection outside the building was done using a drone as most roofs were not accessible. The drone made it easier to inspect the gutters, considering that almost all buildings suffer from water infiltration.

Although the purpose of the visit was to inspect the roofs,CDM also expressed concerns about the cracks on the walls during the kick-off meeting, hence RHDHV also conducted a high-level inspection of these elements.

The inspection included the identification, registration and diagnosis of anomalies that occurred. The anomalies were observed and classified, in order to assign a classification to their state of conservation and maintenance. A general classification of the roof was attributed for each building.

Special attention was paid to Pack Hall, Un/Loading Bay and Old Cellars buildings as these were the most affected.

4 Findings

4.1 Description of Findings for Each Building

4.1.1 Main Entrance

The Main Entrance is a new building and it showed no signs of damage. The roof structure and roof sheets are in a good condition and repairs are not necessary.

4.1.2 Administration Offices

The Administration Offices, similarly to the main entrance, is also a new building. The roof does not present any damages and the gutters are functional. There is no need for any repairs.

4.1.3 Brew House

The Brew House has a self-supporting roof and it is in good condition. The roof slab on the staircase shows signs of infiltration and one of the offices inside the brew house shows signs of stormwater ingress. There seems to be no problems with the gutters. New impermeabilization must be applied.

This building requires special attention to the structure below the roof itself which has significant damage to the columns and must be addressed as soon as possible. Some concrete columns may have rotated causing the concrete to loosen where it is fixed to a connection beam. Specialized tests must be done to determine the extent of the damage and the resistance to the elements.

4.1.4 Old Cellars

The Old Cellars is an old building (around 60 years old) and there seems to be no maintenance of its structure. It is one of the buildings that was most affected by the cyclones. Half of the roof sheeting is gone due to the strong winds leaving the roof structure exposed and the remaining roof sheeting is severely corroded.

The roof trusses can still be used but need proper treatment and maintenance. The purlins and roof sheeting must all be replaced. There is currently no rainwater collection system, such as, through roof gutters and a completely new system of roof stormwater collection must be installed.

The rest of the building also requires intense repairs. Some elements of the steel structure show signs of corrosion but can be repaired and treated, where the connections appear to be intact. But some columns present an advanced state of corrosion and require replacement.

This building is still operational even though half the roof sheeting is gone, leaving the structural and its contents exposed to the elements. This building requires immediate attention.

4.1.5 Canteen and Filtration

The Canteen’s roof structure was recently rebuilt but the concrete gutters were not rehabilitated. There are three whirlybirds (turbine vents) on the roof that have moved. This may allow water ingress into the building. The whirlybirds must be put back in the correct place and the concrete gutters must be cleaned, waterproofed and maintained.

The waterproofing membrane on the slabs of the filtration room is worn and no longer have the required properties. There are signs of accumulated humidity, with air pockets and sections of the membrane that are loose and therefore the ceilings below display signs of accentuated stormwater infiltration. The waterproofing membranes must be substituted.

4.1.6 Laboratory and Technical Building

It was not possible to inspect the roof structure of the laboratory from the inside because of the ceiling but signs of stormwater infiltration was visible. With the images taken from the drone, it was possible to see that the lateral roof flashing is missing, and this causes the water ingress. This issue must be addressed by installing new roof flashing.

The waterproofing membrane on the slab of the technical building must be repaired. It is not sealed properly between the lateral wall and the roof structure of the next building allowing water ingress and causing infiltration marks on the walls.

It is important to address a situation of settlement happening in the building. There are cracks on the floors and large cracks along the walls on the ground floor. Specialized tests must be done to determine the extent of the damage and whether these cracks are propagating. This should be done as soon as possible.

4.1.7 Pack Hall (Area 7)

The Pack Hall represented in area number 7 of figure 2, has many problems including corrosion of steel elements, infiltration and the rainwater collection system that is inefficient. Although the roof trusses show signs of corrosion, this is not severe and may be treated, however, the roof sheeting must be replaced.

The gutters are in a very poor condition and must be replaced. Their condition allows water into the building which presents a risk to the occupants, the property and the hygiene of the products. Some of the windows at the top of the walls are broken also allowing water inside the building. These issues should be addressed.

The roof slabs have severe cases of infiltration, this must be treated and waterproofing applied.

What is more concerning about this building are the cracks on the walls of the chlorine dosing room. There seems to be differential settlement of the building as the floor is visibly lower and cracked which caused one wall to rotate, thus cracking and disconnecting from the top slab. Specialized tests must be done to determine the extent of the damage and the affected walls must be rebuilt. It is not recommended to use these rooms while the walls are in this state as it represents great danger to the people working close to it.

4.1.8 Pack Hall (Area 8)

The Pack Hall represented in area number 8 of figure 2, had a portion of the roof removed during the last cyclone, for this reason that portion received new roof trusses similar to the old ones, but the roof sheet has not been replaced yet. This is an old building and the connections have proved to not be able to withstand strong winds and cyclones.

The roofing sheets are worn, and the steel elements show signs of corrosion. The gutters are in an advanced state of degradation with several points of corrosion. It recommended that the whole roof structure and drainage system are replaced.

4.1.9 Fulls Warehouse

The roof structure of the Fulls Warehouse has recently been replaced with roof trusses and it is observed to still be in good condition,. No repairs or replacement necessary.

4.1.10 Finished Goods Warehouse

The Finished Goods warehouse has an old self-supporting roof structure that shows many signs of corrosion, there are visible holes in the roof. It is recommended that this structure is replaced by a new one similar to the fulls warehouse.

It was noted that a concrete beam covering one of the spans has been hit and is severely damaged and it has also caused cracks on the wall. It is recommended that demolition of this part of the wall including the concrete beam.

4.1.11 Empty Bottles Warehouse

The roof structure of the Empty Bottles warehouse, similarly to the Fulls Warehouse, has recently been replaced with roof trusses and it is observed to still be in good condition. No repairs or replacement necessary.

4.1.12 Logistics Meeting Room

The Logistic Meeting room has a new roof and is observed to be in good condition. The small warehouse next to it has been affected by the cyclones and part of its self-supporting roof is missing due to the wind. It is clear that this is an old roof with signs of degradation, and it cannot withstand the strong winds and cyclones. The replacement of this roof structure is recommended.

4.1.13 Un/Loading Bay – North

This section was recently rebuilt, the roofing sheeting, structural elements and gutters are new. Some problems were noted after the cyclone, including the ridge cap that was affected; a small section disintegrated from the attachment point. This type of damage was also seen with sections of the roofing sheeting. It is recommended that the roof sheeting affected is replaced with thicker sheeting and a new ridge cap is installed.

4.1.14 Un/Loading Bay – South

This section of the Un/Loading bay was not rebuilt and during the last cyclone the ridge cap was blown off by the wind leaving an opening thus allowing water to enter through this open area to the operation zone. It is visible that the roof sheeting has degraded from corrosion. Little holes can be seen in the roof. The steel structure also show signs of corrosion. The structural roof elements can be treated against corrosion but the roof sheets and gutters must be replaced, and a ridge cap installed.

4.1.15 Change Rooms

Some of the roof sheets of the Change Rooms have been replaced but the structural elements remained the same. The steel elements show signs of corrosion but are not severe. They must be treated against corrosion.

The drainage system is functional, but some walls show signs of infiltration. Impermeabilization is required.

4.1.16 Old Chibuko House

The roof structure of the Old Chibuko House was recently re-built and changed from wood to steel trusses. There is no rainwater collection system through gutters. There is a significant overhang of the roof and the last purlin is not supported by the roof truss. This may cause suction and potential up-lift of the roof. A design review of the new roof structure should be performed to determine the potential up-lift of this roof during a cyclone.

4.1.17 Raw Materials Warehouse

The Raw Materials Warehouse was also recently re-built and changed from wood to steel trusses, but the gutters were not rehabilitated. There are concrete gutters that show signs of no maintenance throughout the

years and do not seem to be functional resulting in infiltration into the building. These gutters need repairs and waterproofing.

4.1.18 Water Treatment Plant

The Water Treatment Plant is functional and shows no signs of damage. The roof structure and roof sheets are in good condition and repairs are not necessary.

4.1.19 Silos Building

The silos building has a concrete roof slab and the waterproofing is in poor condition. There are signs of accumulated humidity, some portions are raised with air pockets and are loose. For these reasons the ceilings below present accentuated stormwater infiltration. The infiltration must be treated, and a new waterproofing membrane must be installed.

In the adjacent building it was noted that one of the lateral roof sheets was missing. This must be replaced.

4.1.20 CO_2 Plant

On rainy days a significant amount of water enters the building from the openings between the walls and the roof and therefore the electrical panel has been temporarily protected with plastic. After inspecting it the team concluded that the water coming into the building is not due to a faulty drainage system, but due to the opening that is large enough to allow the stormwater to enter when the wind is strong. This can be corrected by closing the gap and adequate sealing off.

4.1.21 Malt Intake

The roof of the Malt Intake is an old self-supporting structure that has signs of corrosion and was affected by the cyclone. One of the roof sheets was blown off by the wind leaving an opening on the roof. The roof sheet must be replaced.

The roof supporting steel structure could not be seen due to inaccessibility. This will have to be inspected when the roof is removed, and treatment/corrosion protection shall be applied to it or it shall be replaced if found inadequate.

4.1.22 Engine Room

The Engine Room has a concrete roof slab and the waterproofing is in poor condition. There are signs of accumulated humidity, some portions are raised with air pockets and are loose. For these reasons the ceilings below present accentuated stormwater infiltration. The infiltration must be treated, and a new waterproofing membrane must be installed.

4.1.23 Boilers

The roof and gutters of the Boilers are in a degraded condition, showing a lot of corrosion. The roof sheets and gutter need replacement. The roof structural elements also show signs of corrosion but could not be properly inspected due to inaccessibility. Extensive replacement of the whole roof may be required if found inadequate.

4.1.24 Residence 1

The Residence 1 is not in use and was not part of the guided visit but it is property of CDM hence the drone was used to inspect it. Parts of the roof is missing which indicated that stormwater goes into the building when it rains. The whole house needs rehabilitation and the roof structure should be replaced.

4.1.25 Residence 2

The Residence 2 is not in use and was not part of the guided visit but it is property of CDM hence the drone was used to inspect it. Parts of the roof is missing which indicated that stormwater goes into the building when it rains. The whole house needs rehabilitation and the roof structure should be replaced.

4.2 Summary of the Findings

The table below summarizes the findings of the inspection. It indicates the current state, anomalies found, the state of conservation and general classification for each building.

The general classification rating scale is as follows:

Good – Good condition. Does not need any repairs / needs minor maintenance.

Fair – Mild condition. Need repairs but it is not critical.

Poor – Poor condition. Need urgent repairs.

Table 1: Summary of findings

	Building	Current State	Anomalies	State of Conservation	General Classification
1	Main Entrance	Functional	Not found	No repairs / replacements necessary	Good
2	Admin. Offices	Functional	Not found	No repairs / replacements necessary	Good
3	Brew House	Presents a risk to people and goods	- Infiltration on the staircase. - Water dripping from the ceiling on rainy days in one office. - Movement of concrete columns causing concrete detachment.	Needs repairs	Poor
4	Old Cellars	Presents a risk to people and goods	- Missing roof sheets. - Corrosion of roof structural elements. - Corrosion of steel columns. - Infiltration	Needs replacements	Poor
5	Canteen and Filtration	Functional	- Gutters lacking maintenance. - 3 whirlybirds misplaced. - Worn waterproofing membrane. - Infiltration on the ceiling.	Needs repairs	Fair

Building		Current State	Anomalies	State of Conservation	General Classification
6	Lab./Technical Build.	Presents a risk to people and goods	- Infiltration on the ceiling and walls. - Missing lateral roof flashing. - worn waterproofing membrane on the roof slab. - Poor sealing between the wall of the technical building and the roof of the pack hall. - Cracks on the 1st floor slab. - Large cracks along the walls.	Needs repairs	Poor
7	Pack Hall	Presents a risk to people and goods	- Corrosion of roof steel elements. - Infiltration on the ceiling and walls. - Gutters in poor condition causing the water to pour inside the building on rainy days. - Large cracks on the walls. - Floor settlement. - Detachment of the walls. - Broken windows.	Needs replacements	Poor
8	Pack Hall	Presents a risk to goods	- Missing part of the roof, leaving it open and exposed to all weather conditions. - Corrosion of all roof steel elements. - Gutters in advanced state of degradation.	Needs replacements	Poor
9	Fulls Warehouse	Functional	Not found	No repairs / replacements necessary	Good
10	Finished Goods Warehouse	Presents a risk to goods	- Corrosion (holes in the roof). - Damaged concrete beam and cracked wall. - The roof between the empty bottles warehouse and the logistics meeting room shows signs of corrosion and has a portion of the roof missing, leaving an open space subject to all weather conditions.	Needs replacements	Poor
11	Empty Botles Warehouse	Functional	Not found	No repairs / replacements necessary	Good
12	Logistics Meeting Room	Functional	Not found	No repairs / replacements necessary	Good

Building		Current State	Anomalies	State of Conservation	General Classification
13	Un/Loading Bay - North	Presents a risk to goods	- Missing last portion of the ridge cap. - Torn and detached end roof sheets.	Needs repairs	Fair
14	Un/Loading Bay - South	Presents a risk to goods	- Missing the whole ridge cap. - Corrosion of all steel elements (holes in the roof). - Gutters in degrading condition.	Needs replacements	Poor
15	Change Rooms	Presents a risk to people	- Corrosion of still elements. - Infiltration on the walls.	Needs repairs	Fair
16	Old Chibuko House	Functional	No anomalies found but there is a significant overhang and openings which are not suitable for strong winds.	Needs repairs	Fair
17	Raw M. Warehouse	Presents a risk to goods	- Concrete gutters in poor condition. - Infiltration on the walls.	Needs repairs	Fair
18	Water Treatment Plant	Functional	Not found	No repairs / replacements necessary	Good
19	Silos Building	Presents a risk to people and goods	- Waterproofing of the roof slab in poor condition. - Infiltration on the ceilings. - One lateral roof sheet missing in the adjacent building.	Needs replacements	Poor
20	CO_2 Plant	Presents a risk to people and goods	No anomalies found but there is a gap between the roof cover and the walls that allow the rainwater to pour in.	Needs repairs	Fair
21	Malt Intake	Presents a risk to goods	- Corrosion on the roof. - Missing a portion of the roof.	Needs replacements	Poor
22	Engine Room	Presents a risk to people and goods	- Waterproofing of roof slab in poor condition. - Infiltration on the ceiling.	Needs repairs	Poor
23	Boilers	Presents a risk to goods	Advanced state of corrosion on roof and gutters.	Needs replacements	Poor
24	Residence 1	Not functional	- Roof in advanced state of degradation. Missing some portions of the roof. - Cracks.	Needs replacements	Poor
25	Residence 2	Not functional	- Roof in advanced state of degradation. Missing some portions of the roof. - Cracks.	Needs replacements	Poor

5 Conclusions and Recommendations

Almost all buildings present the same anomalies: corrosion, infiltration, gutters and waterproofing membranes not functioning properly and worn roof sheets. It is clear that the buildings that require immediate attention are the Old Cellars, the Pack Halls, the Un/Loading Bay (South), the Brew House and the Laboratory and Technical Building.

Most of the slabs waterproofing systems are no longer functioning properly, practically all ceilings have very visible signs of infiltration and often the stains are brownish and reddish, which may be the result of the contact of water with rebars. The infiltrations weaken the slabs and the industrial environment produces a vibration that can cause serious problems to the structure.

It is essential that the services of recovery and repair of the occurrences presented in this document are carried out as soon as possible, so that the functionality and durability of the structure is guaranteed and increased. Any corrosion seen should be addressed as part of general maintenance to ensure prolonged life span of the members.

It is recommended the stormwater system be redesigned to facilitate adequate rainwater collection and management from the roofs through gutters and discharged appropriately.

It is also recommended that a maintenance plan be drawn, with periodic inspections, which will contribute to increasing the life span of the buildings.

The scope of works was to assess only the roof elements but in some buildings the damages caused in the structure were very noticeable and present a great danger to people and property and for that reason the RHDHV team could not leave these findings outside this report.

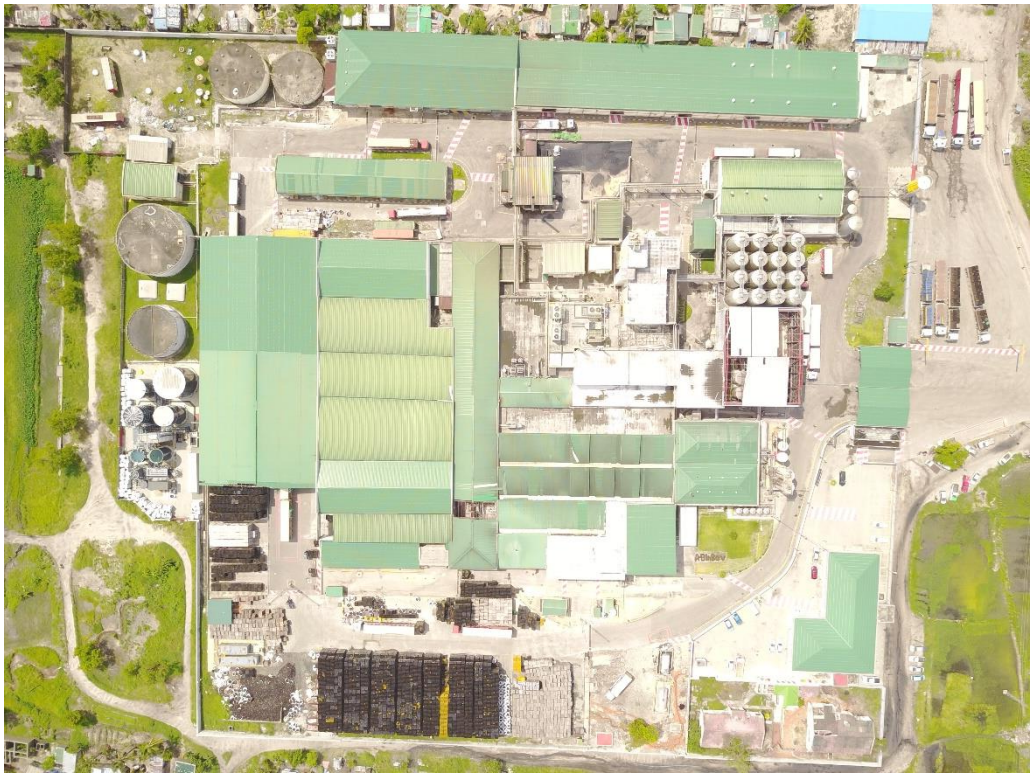
The reported situations related to the large cracks on the walls, settlements, damaged concrete structural elements in the Pack Hall, Brew House, Finished Goods Warehouse and Laboratory and technical building, should be addressed immediately due to risk of collapse.

Appendix 1: Photographic Report

1. Overview of the brewery (front)

2. Overview of the brewery (lateral)

3. Overview of the brewery (back)

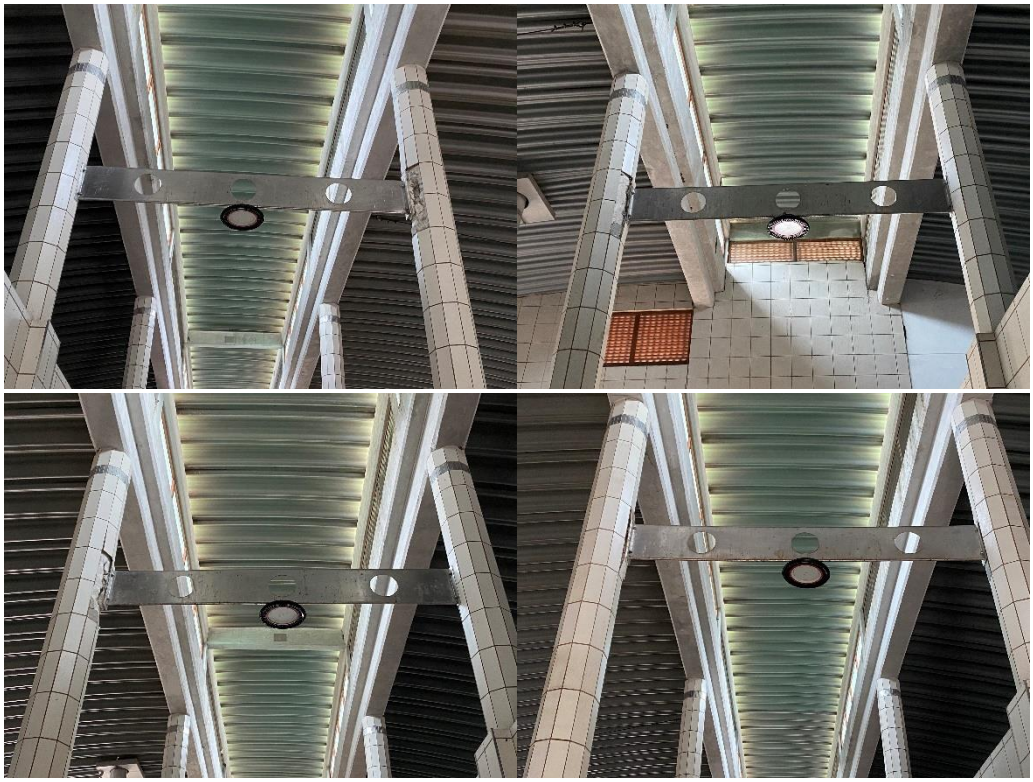


4. Overview of the brewery (top view)

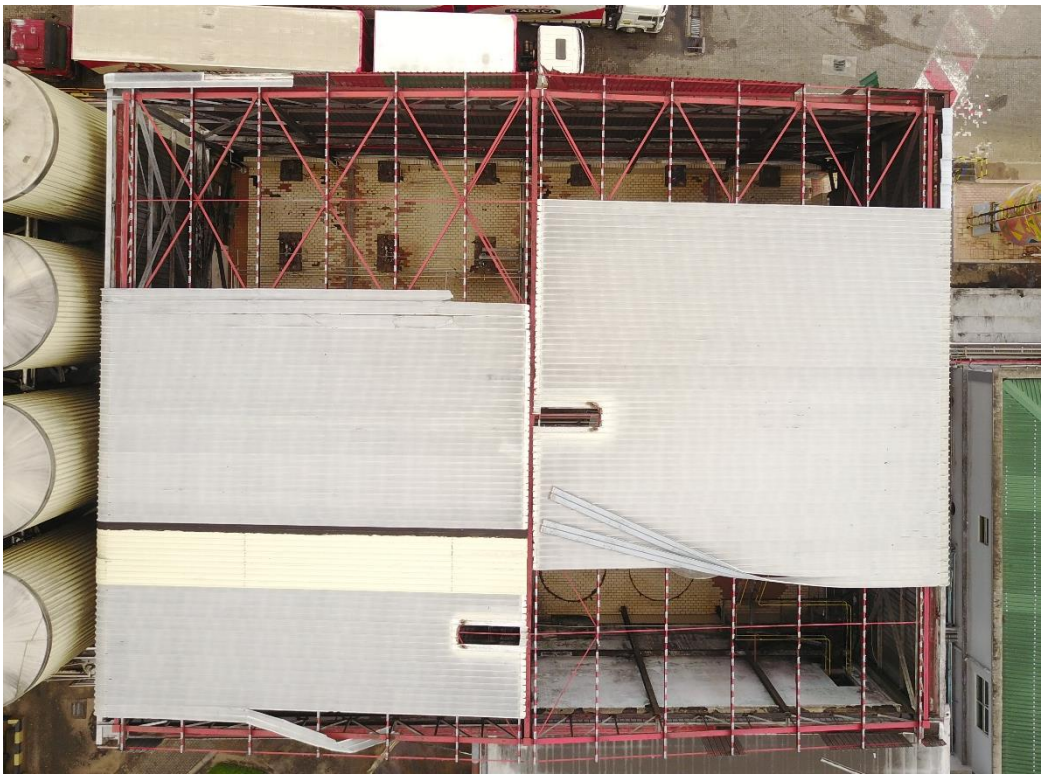
5. Main entrance

6. Administration offices

7. Brew House: damaged concrete columns



8. Brew House: closer look at damaged concrete columns showing detachment of concrete



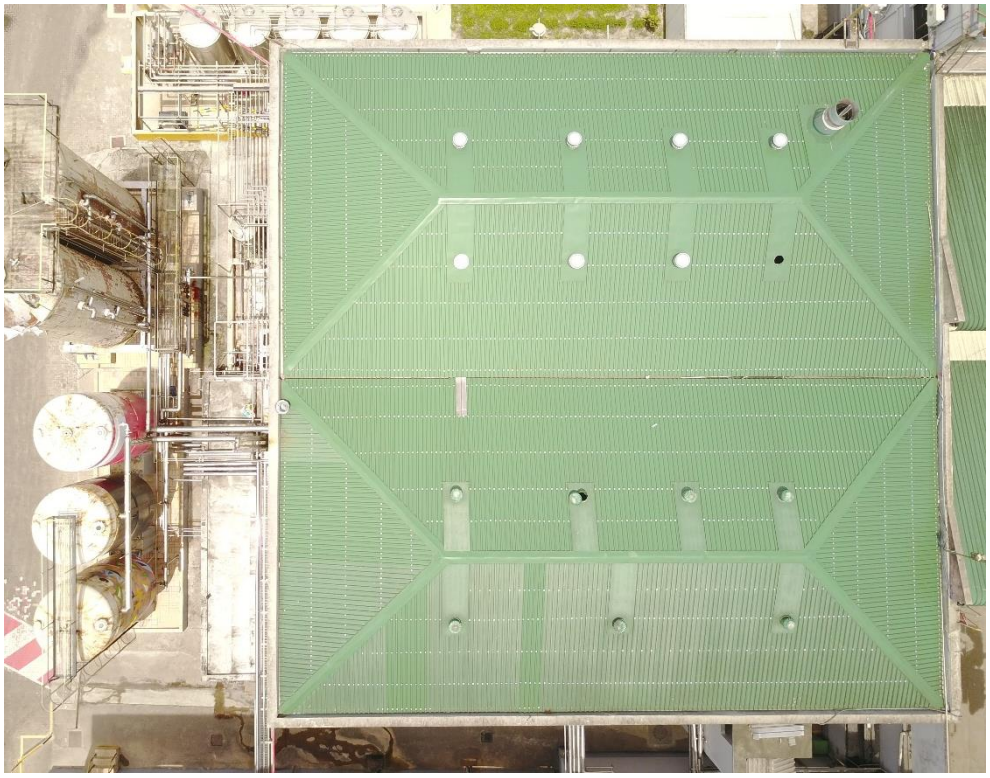
9. Old Cellars: top view

10. Old Cellars: roof view from inside the building

11. Old Cellars: view inside the building showing the damages in the supporting structures

12. Old Cellars: another view from inside the building

13. Old Cellars: structural column with advanced state of corrosion

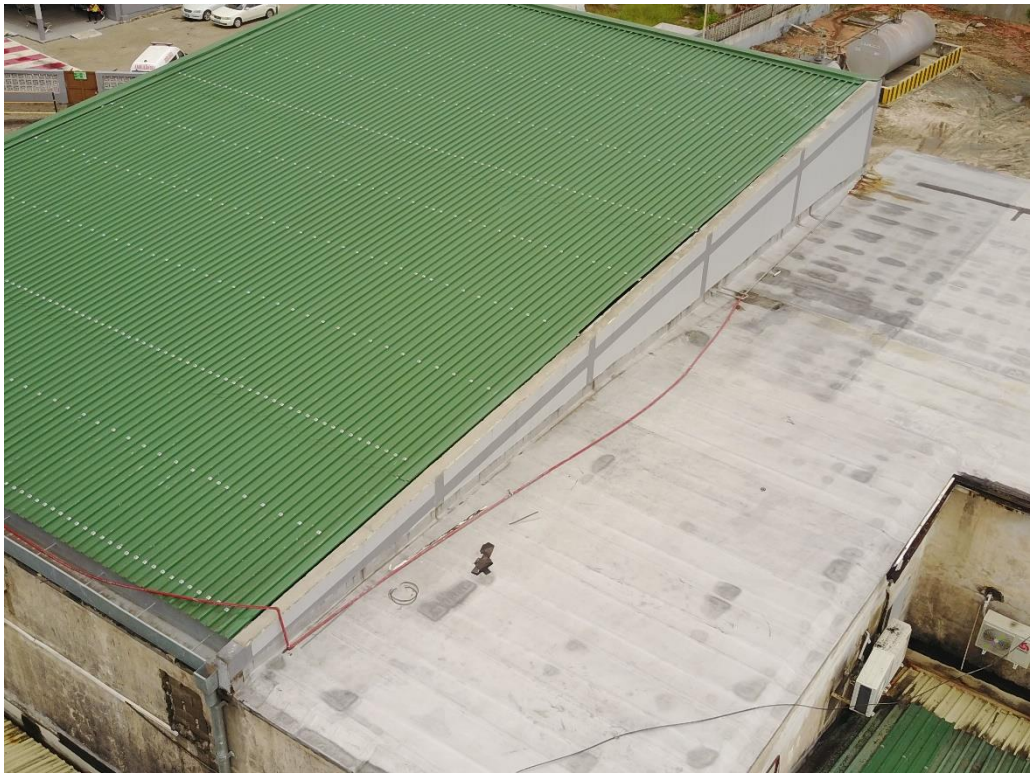


14. Canteen and Filtration: top view (misplaced whirlybirds)

15. Canteen and Filtration: closer top view of filtration room (bushes growing on the roof)

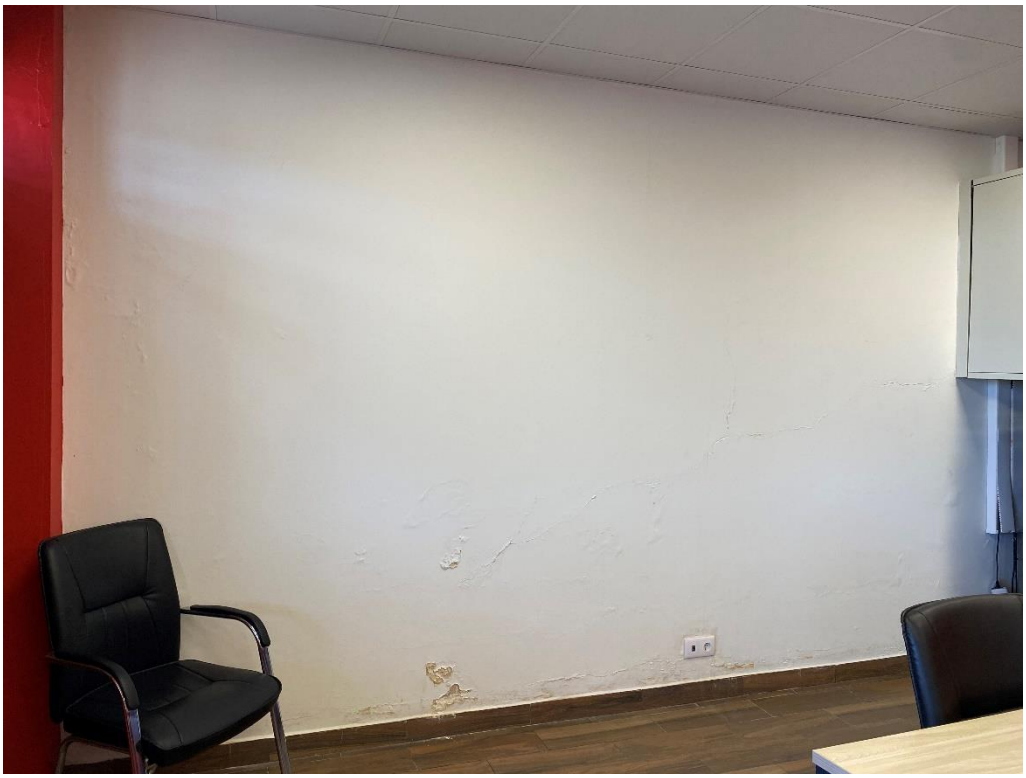
16. Canteen and Filtration: water infiltration on the slab soffit of filtration room

17. Laboratory and Technical Building: overview of the building



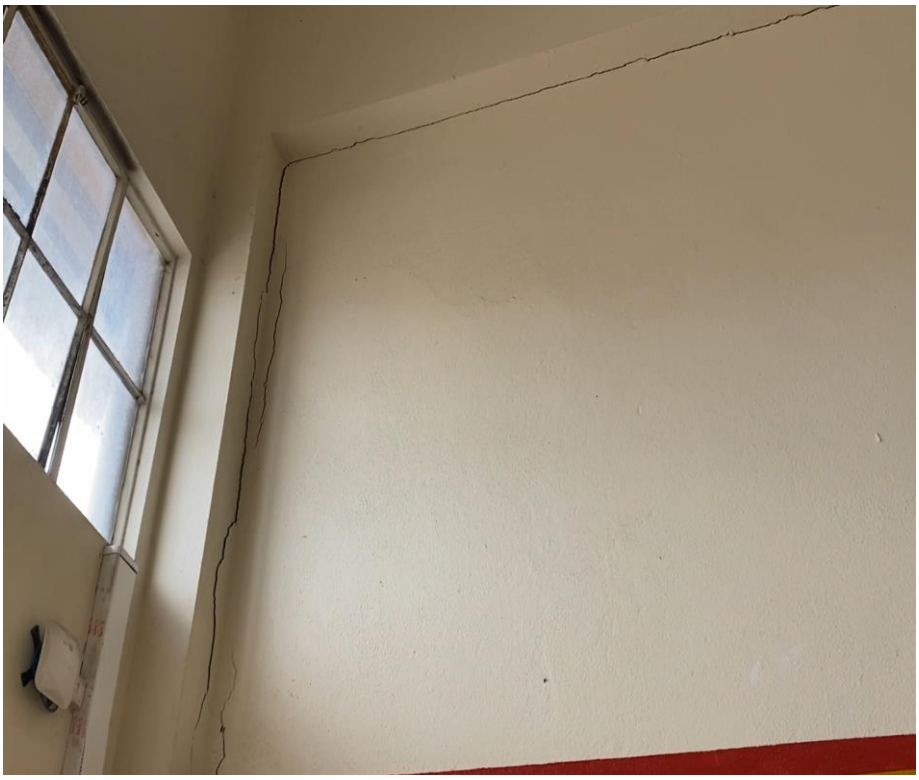
18. Laboratory and Technical Building: no flashing

19. Laboratory and Technical Building: water infiltration in the slab soffit



20. Laboratory and Technical Building: infiltration in the wall

21. Laboratory and Technical Building: large cracks in the walls



22. Laboratory and Technical Building: large cracks in the walls

23. Laboratory and Technical Building: large cracks in the walls

24. Laboratory and Technical Building: large cracks in the floor

25. Pack Hall: top view

26. Pack Hall: gutter and waterproofing in poor condition

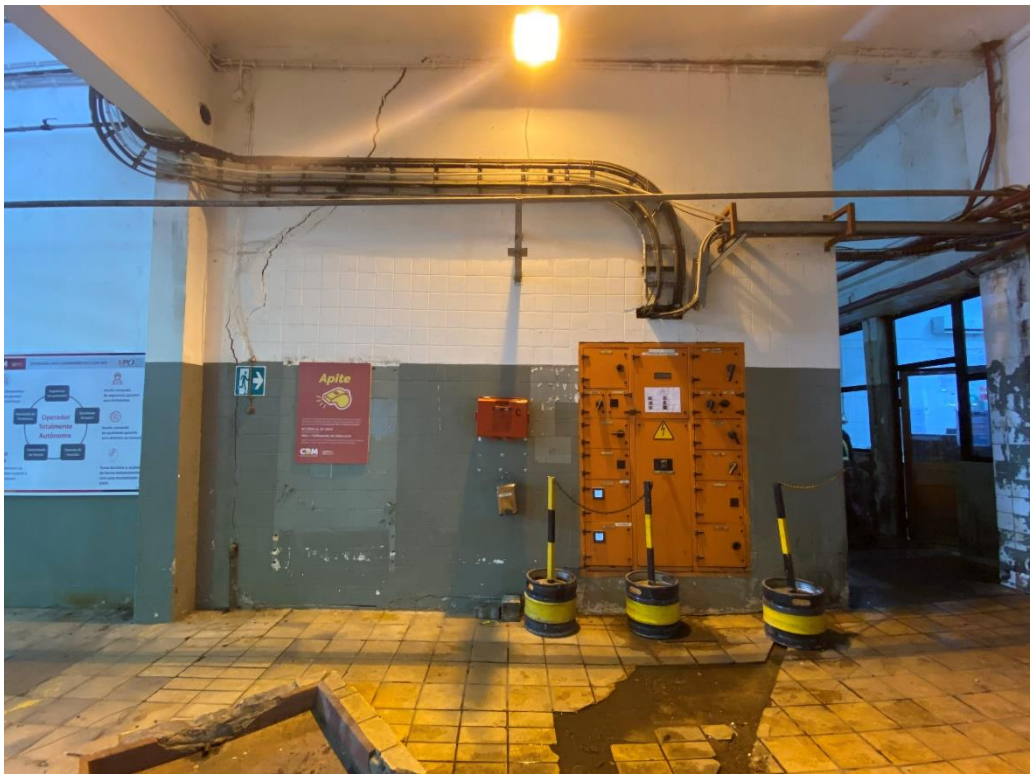
27. Pack Hall: gutter and waterproofing in poor condition

28. Pack Hall: broken windows

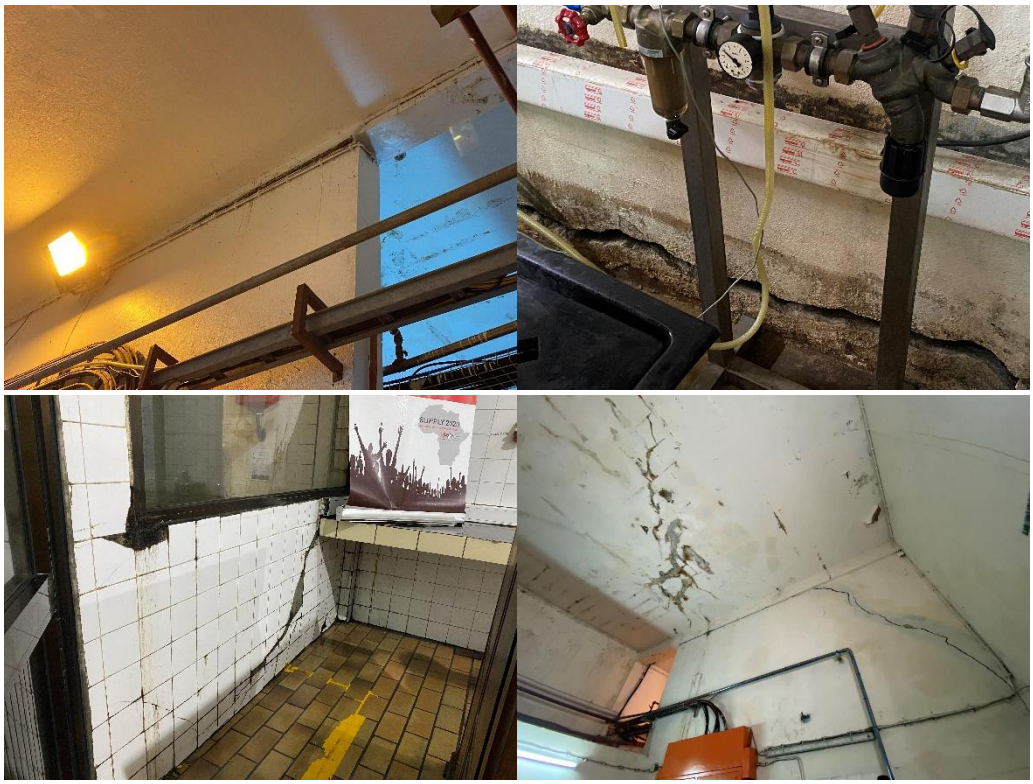
29. Pack Hall: poor drainage system on the roof slab

30. Pack Hall: Water Infiltration Due to Defective Waterproofing

31. Pack Hall: gutter in degrading condition



32. Pack Hall: cracks in the walls and visible settlement of the floor



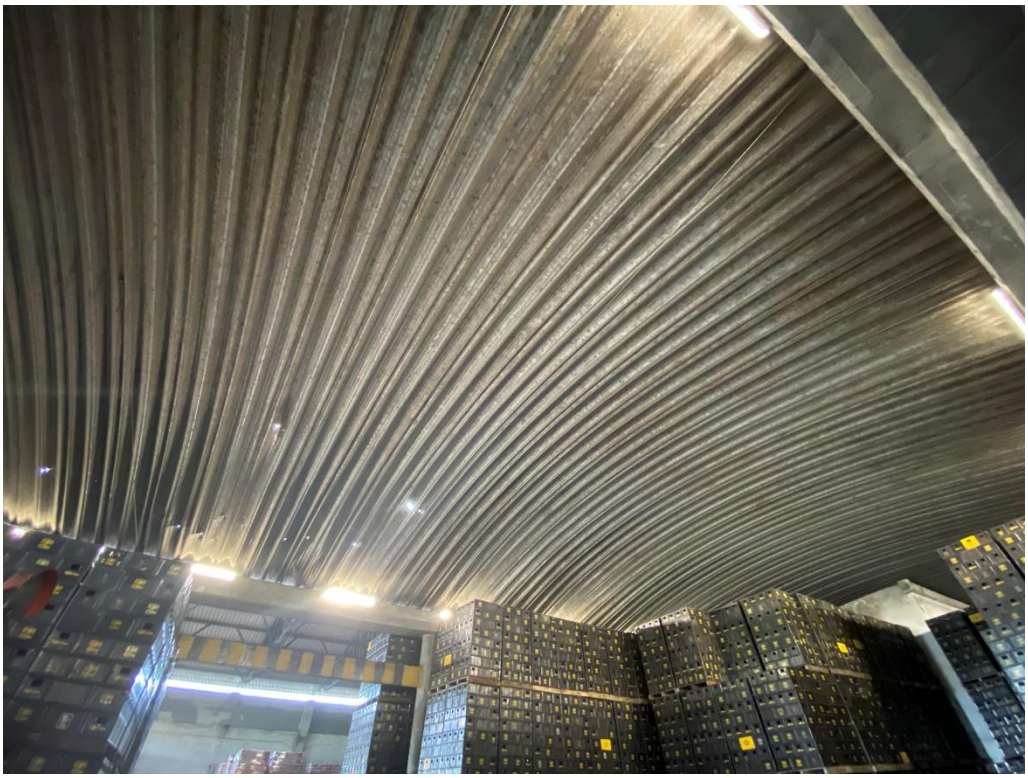
33. Pack Hall: detachment of the wall, cracks and water infiltration

34. Pack Hall: part of the tunnel uncovered

35. Pack Hall: roof with signs of corrosion

36. Top view of warehouses, logistics meeting room and un/loading bays

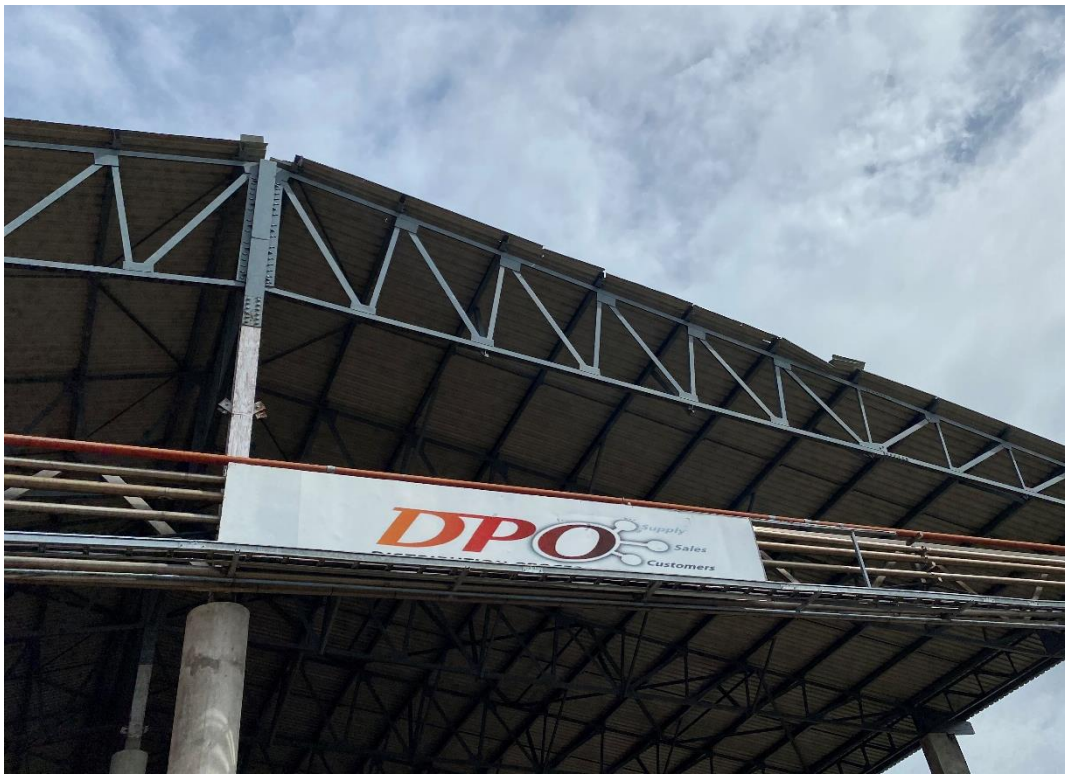
37. Fulls Warehouse: new roof structure



38. Finished Goods Warehouse: self-supporting roof structure with signs of corrosion

39. Finished Goods Warehouse: cracks in the beam and wall

40. Roof between the empty bottles warehouse and the logistics meeting room



41. Un/Loading Bay – North: new roof with torn sheets at the end and missing ridge cap

42. Un/Loading Bay – South: roof missing the ridge, torn sheets and corroded roof structure

43. Un/Loading Bay: difference between the new and old roof

44. Change Rooms: overview

45. Change Rooms

46. Old Chibuko House: overview

47. Old Chibuko House: roof structure in fairly good condition

48. Old Chibuko House: long overhangs

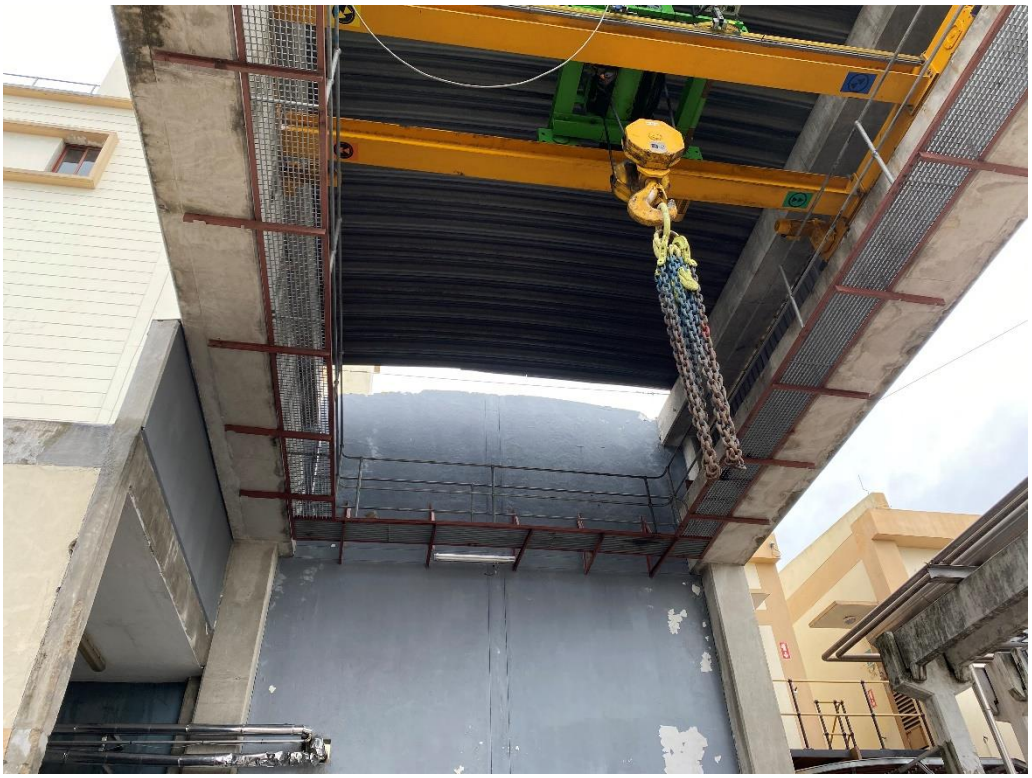
49. Raw Materials Warehouse: overview

50. Raw Materials Warehouse: concrete gutter in poor condition

51. Silos Building: overview

52. Silos Building: water infiltration in the slab soffit (different floors)

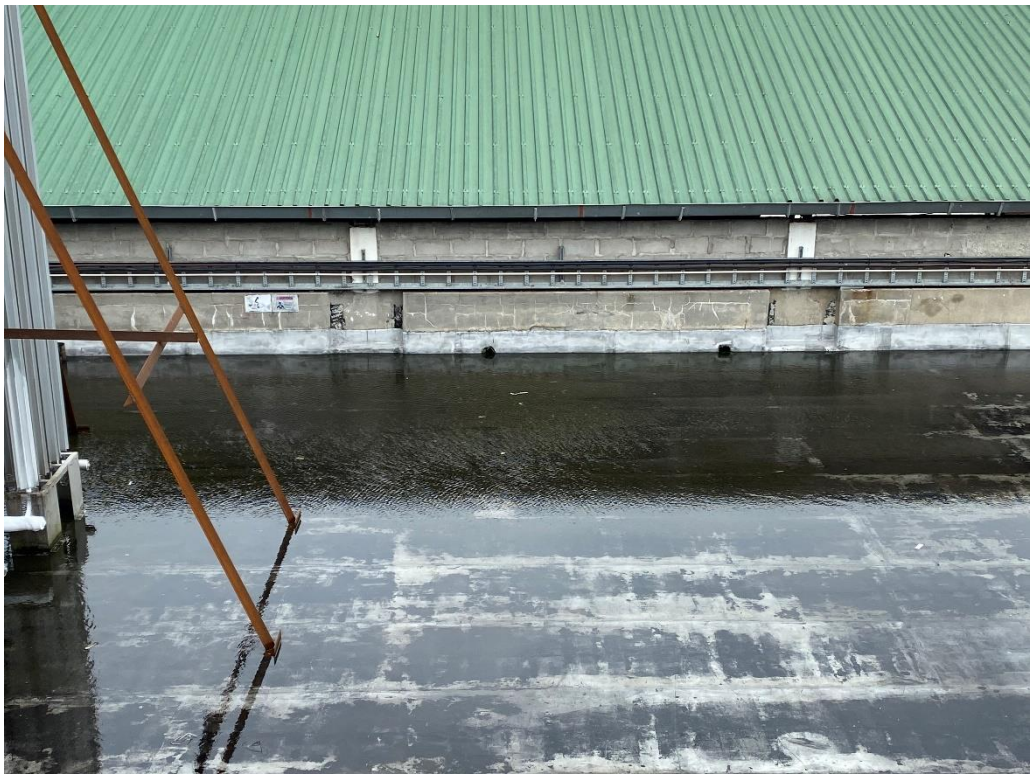
53. CO_2 Plant: opening that allows rainwater inside the building



54. Malt Intake: uncovered portion of the roof

55. Engine Room: overview

56. Engine Room: water infiltration in the ceiling



57. Engine Room: roof slab with inefficient drainage system

58. Boilers: overview

59. Boilers: corrosion in gutter and roof

60. Residences: roofs in advance state of degradation