

## CITY OF JOHANNESBURG ORGANIC WASTE TO BIOMETHANE FOR BUS FUEL PLANT

### STRUCTURAL WORKS

**DECEMBER 2019**  
REVISION 0



Prepared by:

**JG AFRIKA (PTY) LTD**

JOHANNESBURG

37 Sunninghill Office Park, Peltier Drive, Sunninghill, 2191

+27 (0)11 231 2200

Email: [johannesburg@jgafrika.com](mailto:johannesburg@jgafrika.com)

Project director: Cecilia Canahai

|                          |              |
|--------------------------|--------------|
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**CARRIED OUT BY:**

**JG AFRIKA (PTY) LTD**  
**CAPE TOWN**

14 Central Square,  
Pinelands  
7405

Tel.: +27 21 530 1800

Email: [daviso@jgafrika.com](mailto:daviso@jgafrika.com)

**COMMISSIONED BY:**

**ENERGiDROP (PTY) LTD**

Pretoria  
94 Azalea Road  
84 Saartjesnek SN 84-19-5  
Florapark AH  
0216

Tel: +27829681130

Email: [darius@energidrop.com](mailto:darius@energidrop.com)

**AUTHOR**

O Davis

**CLIENT CONTACT PERSON**

D.R.K. Boshoff

**SYNOPSIS**

The report focuses on the concept structural design for a 50 tonnes per day organic waste to bio-methane plant, for the University of Johannesburg (UJ), in collaboration with the City of Johannesburg Metropolitan Municipality. JG Afrika have been sub-contracted to EnergiDrop (Pty) Ltd.

**KEY WORDS:**

Structural, Biogas, Bio-methane, UJ, CoJ

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**QUALITY VERIFICATION**

This report has been prepared under the controls established by a quality management system that meets the requirements of ISO 9001: 2015 which has been independently certified by DEKRA Certification.



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|----------------|---------------------|-------------------------|-----------|------------|
| By Author      | Executive Associate | O. Davis<br>Pr Tech Eng |           |            |
| Checked by:    | Associate           | R. Jarratt Pr Eng       |           | 19/12/2019 |
| Authorised by: | Executive Associate | O. Davis<br>Pr Tech Eng |           |            |

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# **CITY OF JOHANNESBURG ORGANIC WASTE TO BIOMETHANE FOR BUS FUEL PLANT STRUCTURAL WORKS CONCEPT DESIGN REPORT**

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- 4917-S-301-P\_Rev A\_Waste Processing Building
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# **CITY OF JOHANNESBURG ORGANIC WASTE TO BIOMETHANE FOR BUS FUEL PLANT STRUCTURAL WORKS CONCEPT DESIGN REPORT**

## **1 INTRODUCTION**

The University of Johannesburg (UJ), in collaboration with the City of Johannesburg (COJ) has launched the Biomethane Project which aims to produce biomethane as bus fuel from clean organic waste produced by the Johannesburg Fresh Produce Market (JFPM). The facility will function as a commercially operated demonstration plant for the organic waste processing, biogas production and biomethane filling into busses.

Energidrop (Pty) Ltd was appointed by UJ in April 2018 to undertake the professional services for the conceptual design and specification of a biomethane plant (reference number RFP UJ 01/2018). Energidrop appointed JG Afrika (Pty) Ltd as sub-consultants to assist with the civil and structural conceptual design of the facility.

This report focuses on the conceptual design of the structural works.

## **2 SCOPE OF WORK**

The purpose of this report is to inform the City of Johannesburg and University of Johannesburg on the following conceptual design level requirements for the following structures: -

- Process building
- Primary and secondary digester foundations
- Digestate liquor tank foundations
- Pump room
- Biogas upgrading plant
- Mincerator building
- Digestate dewatering building
- Potential sludge drying building
- Biogas and booster filling compressor foundations
- New control room, ablutions and mess building
- Management and weighbridge control office
- Weighbridge foundations
- Foundations and plinths for various equipment and plant

A conceptual-level cost estimate for the above structures will be provided.

### 3 LOCALITY AND DESCRIPTION OF PROPOSED DEVELOPMENT

#### 3.1 LOCALITY

The site for the plant is located on the Robinson Deep Landfill ERF. Access to the facility is on Turffontein Road and is shared with the main Robinson Deep landfill entrance as well as the entrance to the Pikitup offices on site. Figure 3-1 shows the location of the proposed biomethane plant in relation to the Robinson Deep Landfill Site.



*Figure 3-1: Location of the Future Biomethane Plant*

#### 3.2 DESCRIPTION

The area allocated for the biomethane plant has a total land area of  $\pm 1.1$  hectare (including the weighbridge entrance area). The area was initially used as a brick quarry for the City which was subsequently converted into a hazardous waste incineration facility. The incinerator was later shut down as it did not meet the air emissions specifications within the CoJ. The tasks of removal of the old incineration plant and disposal thereof as well as the rehabilitation of the existing buildings for use in the biomethane production process, form part of this project. The stand is currently block paved with visible damage and ponding to the paving. Most of the existing buildings and infrastructure require repurposing for the operations of the biomethane plant.

### 4 BASIS OF DESIGN

The structural engineering scope includes the design of all concrete, load bearing masonry, structural timber and structural steel elements within the scope of work. The design scope is extended to structures that are required to house the specialised plant, equipment and processes.

All relevant SANS codes of practice are to be used for structural analysis purposes. The European codes will be applied where necessary, specifically for the design of water retaining concrete structures.

The standards and specifications to be used for the detailed structural design of the project are listed below.

#### 4.1 Loading

- SANS 10160-1: Basis of Structural Design and Actions for Buildings and Industrial Structures – Basis of Structural Design.
- SANS 10160-2: Basis of Structural Design and Actions for Buildings and Industrial Structures - Self Weight and Imposed Loads.
- SANS 10160-3: Basis of Structural Design and Actions for Buildings and Industrial Structures - Wind Actions.
- SANS 10160-4: Basis of Structural Design and Actions for Buildings and Industrial Structures - Seismic Actions and General Requirements for Buildings.
- SANS 10160-5: Basis of Structural Design and Actions for Buildings and Industrial Structures – Basis for Geotechnical Design and Actions.
- SANS 10160-6: Basis of Structural Design and Actions for Buildings and Industrial Structures - Actions Induced by Cranes and Machinery.
- SANS 10160-7: Basis of Structural Design and Actions for Buildings and Industrial Structures – Thermal Actions.
- SANS 10160-8: Basis of Structural Design and Actions for Buildings and Industrial Structures – Actions During Execution.

#### 4.2 Foundations

- SANS 10161: The design of foundations for buildings.

#### 4.3 National Building Regulations.

The South African National Building Regulations are to be used as a basis for all building design. The following sub-sections apply:

- SANS 10400-A: The application of the National Building Regulations Part A: General principles and requirements.
- SANS 10400-B: The application of the National Building Regulations Part B: Structural design.
- SANS 10400-C: The application of the National Building Regulations Part C: Dimensions.
- SANS 10400-D: The application of the National Building Regulations Part D: Public safety.
- SANS 10400-F: The application of the National Building Regulations Part F: Site operations.
- SANS 10400-G: The application of the National Building Regulations Part G: Excavations.
- SANS 10400-H: The application of the National Building Regulations Part H: Foundations.



- SANS 10400-J: The application of the National Building Regulations Part J: Floors.
- SANS 10400-K: The application of the National Building Regulations Part K: Walls.
- SANS 10400-L: The application of the National Building Regulations Part L: Roofs.
- SANS 10400-M: The application of the National Building Regulations Part M: Stairways.
- SANS 10400-N: The application of the National Building Regulations Part N: Glazing.
- SANS 10400-O: The application of the National Building Regulations Part O: Lighting and ventilation.
- SANS 10400-P: The application of the National Building Regulations Part P: Drainage.
- SANS 10400-Q: The application of the National Building Regulations Part Q: Non-water-borne means of sanitary disposal.
- SANS 10400-R: The application of the National Building Regulations Part R: Storm water disposal.
- SANS 10400-S: The application of the National Building Regulations Part S: Facilities for persons with disabilities.
- SANS 10400-T: The application of the National Building Regulations Part T: Fire protection.
- SANS 10400-V: The application of the National Building Regulations Part V: Space heating.
- SANS 10400-W: The application of the National Building Regulations Part W: Fire installation.
- SANS 10400-XA: The application of the National Building Regulations.
- Part X: Environmental sustainability
- Part XA: Energy usage in buildings

#### 4.4 Concrete

- SANS 10100-1: The structural use of concrete Part 1: Design.
- SANS 10100-2: The structural use of concrete Part 2: Materials and execution of work.
- Eurocode 2 – Design of Concrete Structures – Part 3: Liquid Retaining and Containment Structures.
- BS 8007 – Design of Concrete Structures for Retaining Aqueous Liquids.

#### 4.5 Steel

- SANS 10162-1: Limit State Design of Hot-Rolled Steelwork.
- SANS 10162-2: Limit State Design of Cold-Formed Steelwork.
- SANS 10162-4: The Design of Cold-Formed Stainless Steel Structural Members.

#### 4.6 Galvanising

- SANS 14713-1: Zinc Coatings — Guidelines and Recommendations for The Protection Against Corrosion of Iron and Steel in Structures - General Principles of Design and Corrosion Resistance.
- SANS 14713-2: Zinc Coatings — Guidelines and Recommendations for The Protection Against Corrosion of Iron and Steel in Structures - Hot Dip Galvanizing.

#### 4.7 Timber

- SANS 10163-1: The Structural Use of Timber – Limit-States Design.



- SANS 10163-2: The Structural Use of Timber – Allowable Stress Design.

#### 4.8 Masonry

- SANS 10164-1: The Structural Use of Masonry – Unreinforced Masonry Walling.
- SANS 10164-2: The Structural Use of Masonry – Reinforced & Prestressed Masonry.
- SANS 10145-1: Concrete Masonry Construction.

#### 4.9 Earthing and lightning protection system

- SANS 10313: Lightning protection and earthing.
- SANS 10199: The design and installation of earth electrodes.

### 5 GEOTECHNICAL INVESTIGATION

The design of the foundation types for the different structures on the site is dependent on the soil conditions. The characteristics of the ground conditions were determined by a geotechnical investigation by JG Afrika and detailed in a report dated May 2019.

The geotechnical investigation indicated that the site is suitable for the construction of a biomethane plant provided that the recommendations given in the report are implemented. The following are important extracts from the report: -

- The poor ground conditions encountered at the proposed location of the weighbridge structure will require substantial ground works.
- It is recommended that stiffened strip footings or a stiffened raft foundation be used for the new office block.
- It is recommended that the new biodigester tanks are founded on an engineered soil raft.
- It is recommended that the new digestate liquor storage tank be constructed above existing ground level to limit the influence of the strong groundwater seepage and be founded on a platform above the expected road layer works, provided that no large loads are expected to be exerted by the digestate tank.

The above recommendations for foundation support are incorporated in the design of the various structures.

### 6 BUILDINGS AND STRUCTURES

The process and mechanical design undertaken by Energidrop had identified the need for various process equipment, storage tanks, building upgrades and refurbishment, administrative, operational and ablutions facilities.

The structural requirements for each building, tank and plinth are outlined below.

#### 6.1 Waste Process Building

The existing incinerator building will be upgraded and refurbished to accommodate the new process equipment and operational requirements. The following will be accommodated in the building: -

- A structural steel platform for the picking line. Access to the platform will be via steel stairs. It is expected that the platform can be constructed directly on the existing floor using spreader plates. These spreader plates to be designed specifically for the expected working loads. Cores of the floor taken during the geotechnical investigation has indicated that the floor is approximately 200mm thick with a concrete compressive strength between 25-30MPa.
- Solar panels to be added on north facing roof. The existing roof structure (steel trusses) is in a relatively good condition and is expected to support the additional loads for the solar panels. Minor strengthening of purlins might be required.
- A pushwall on the west side of the large building will be constructed to allow for the retention of waste heaps. This wall and foundation will be constructed of reinforced concrete to a height of 3m.
- A liquids waste tipping pit connected to the leachate runoff will be constructed. This will take the form of a new concrete sump constructed in the floor. The existing trench will be modified and extended.
- Four-bay access on the southern façade for RoRo bins to be delivered to and collected from the building.
- The existing roof to be lifted to allow for vehicles to comfortably deliver and collect RoRo bins. The existing columns are inadequate and will need to be replaced with new 305x165x40 UB steel columns.
- The existing roof structure to be adapted for ventilation extraction.
- One-bay access on the southern façade for digestate bin to be delivered to and collected from the building.

Reference can be made to drawing 4917-S-301-P-Rev\_A Waste Processing Building, for a conceptual structural layout of the building modifications.

## 6.2 Foundations for the Primary and Secondary Digester, Mascerator Building, Fire Protection System, Biogas Upgrading Plant, Digestate Liquor Storage Tank and Water Treatment Plant

New steel tanks are to be provided on a design and install basis. The steel tanks will be supported on new reinforced concrete foundations constructed on an engineered soil raft. This type of foundation will also be used for the Mascerator Building, Fire Protection System, Biogas Upgrading Plant and Water Treatment Plant.

Reference can be made to drawing 4917-S-601-P-Rev\_A New Plinths Layout, for a conceptual layout of the foundations.

## 6.3 Management and Weighbridge Control Office and Weighbridge foundation structures

The Management and Weighbridge Control Office and the actual Weighbridge is located on the south western side of the site. As indicated in the geotechnical report, this area is particularly susceptible to strong ground water ingress with the founding conditions classified as poor.

The building and weighbridge structures will be founded on reinforced concrete raft foundations.

The building is single-storey with masonry walls supporting a timber truss roof structure.

Reference can be made to drawing 4917-S-101-P-Rev\_A New Admin and Weighbridge Control Office, for a conceptual structural layout of the building.

#### 6.4 New Control Room, Ablutions and Mess Building

The New Control Room, Ablutions and Mess Building is located on the eastern side of the Waste Process Building.

The building is double-storey with masonry loadbearing walls supporting a reinforced concrete first floor slab and timber roof structure. The building will be supported on reinforced concrete strip foundations. Access to the first floor will be via a reinforced concrete stair.

Reference can be made to drawing 4917-S-201-P-Rev\_A New Control, Ablutions & Mess Room, for a conceptual structural layout of the building.

#### 6.5 Foundations and Plinths for smaller plant and Equipment

The smaller plant and equipment will be supported on 300mm deep reinforced concrete foundation constructed on 200mm layer of G5 subbase compacted to 98% modaashto density on well compacted in-situ subgrade.

#### 6.6 Digestate Dewatering Building

The current Workshop Building will be converted into the new Digestate Dewatering Building. The current building is in a good condition and minimal modifications are expected to the existing building.

#### 6.7 Sludge Drying

The current Storeroom Building will be demolished to make way for the Sludge Drying plant. The plant will be supported on a reinforced concrete raft slab and underlying soil raft as described in 6.2.

### 7 DEMOLITIONS

Various existing buildings and structures will be demolished and removed from the site. These include but not limited to the following: -

- The workshop and storage building.
- The storeroom building.
- The container washing bay and canopy.
- The incinerator plant and equipment.
- The fire-damaged incinerator building.
- The pre-fabricated offices in the existing building.
- The canopy on the north side of the existing storeroom and workshop building.

### 8 COST ESTIMATE

The table below lists the structures and building items and their estimated construction costs only.

*Table 8-1: Cost Estimate Structures and Buildings*

| ITEM   | Amounts (excl. VAT)    |
|--|------------------------|
| Waste Processing Building (refurbishment)                  | 4,649,000.00           |
| Control Room, Ablutions & Mess                             | 3,277,000.00           |
| New Equipment Foundations & Plinths                        | 402,000.00             |
| New Tank Foundations & Soil Rafts                          | 5,466,000.00           |
| Weighbridge Control Office                                 | 2,104,000.00           |
| Weighbridge Foundations                                    | 416,000.00             |
| Demolitions  | 2,766,000.00           |
| <b>Sub- total</b>  | <b>R 19,973,000.00</b> |
| Excludes - mechanical equipment, HDPE and steel tanks, etc |                        |
| Excludes - lighting, power, electronics, etc.              |                        |
| Includes - 15% contingency & 15% P&Gs                      |                        |
| Excludes - VAT   |                        |
| Note - pricing based on expected project start in 2020     |                        |

## 9 DETAIL DESIGN CONSIDERATIONS

The conceptual design covers the basic structural aspects of the new structures and buildings for the site. The following aspects will need to be further investigated and/or considered more comprehensively in the detailed design.

- Accommodation schedule of personnel and staff to finalise the facilities and building sizes.
- No existing underground services were verified for the concept design phase. Underground services should be identified, investigated and locations and invert levels verified prior to finalising detailed design.
- The detail design must comply with the design guidelines and standards of the Johannesburg Building Development Branch and it will be required that a building plan submission process is followed prior to construction.

## ***Annexure A: DRAWINGS***

- 4917-S-001-P\_Rev A\_Site Layout-Site Layout
- 4917-S-101-P\_Rev A\_New Admin & Weigh Bridge Control Office
- 4917-S-201-P\_Rev A\_New Control Room, Ablutions & Mess-Control Room
- 4917-S-301-P\_Rev A\_Waste Processing Building
- 4917-S-601-P\_Rev A\_New Plinths Layout-Site Layout