

Attention Paul Jones
 GP Biotec Ltd
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 LD3 0DL

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My Ref : 1541/GAC
 Date:06 June 2022

**1541 : GREAT PORTHAMEL ANAEROBIC DIGESTER FACILITY : DIGESTATE-
 CONTAINMENT BUND WALLS : STRUCTURAL STABILITY ASSESSMENT REPORT**

GA Cohen was instructed by Paul Jones of GP Biotec Ltd to investigate the structural stability of the existing precast concrete bund walls surrounding the AD Plant at at Great Porthamel farm LD3 0DL as follows :-

This Report forms part of the Health and Safety File which is the statutory document prepared pursuant to the Construction (Design and Management) Regulations 2015 - the CDM Regulations. It must be kept up to date and retained for as long as it is relevant by the owners – normally the lifetime of the structure.

Where owners dispose of their entire interest in the structure the H&S file should be passed to the new owners. Where part of the structure is sold any relevant information should be passed to the new owners. If all or part of the structure is leased arrangements need to be made for this file to be made available to leaseholders during the lease period.

Issue	Date Issued	Company (issued to)	Signature (of responsible person)	Comments
Po	06/06/2022	Paul Jones (Owner)	<i>Gregory Cohen</i>	Draft for comment

2.0 SCOPE OF APPOINTMENT

The appointment is in terms of FIDIC Client/Consultant Model Services Agreement and the attached Annexure 1 (Particular Conditions of FIDIC Client/Consultant Agreement) .

This report shall be for the benefit of the addressee only. I accept no liability to any other party who may seek to rely upon the whole, or any part of this report.

The envisaged “normal” structural services are as follows:-

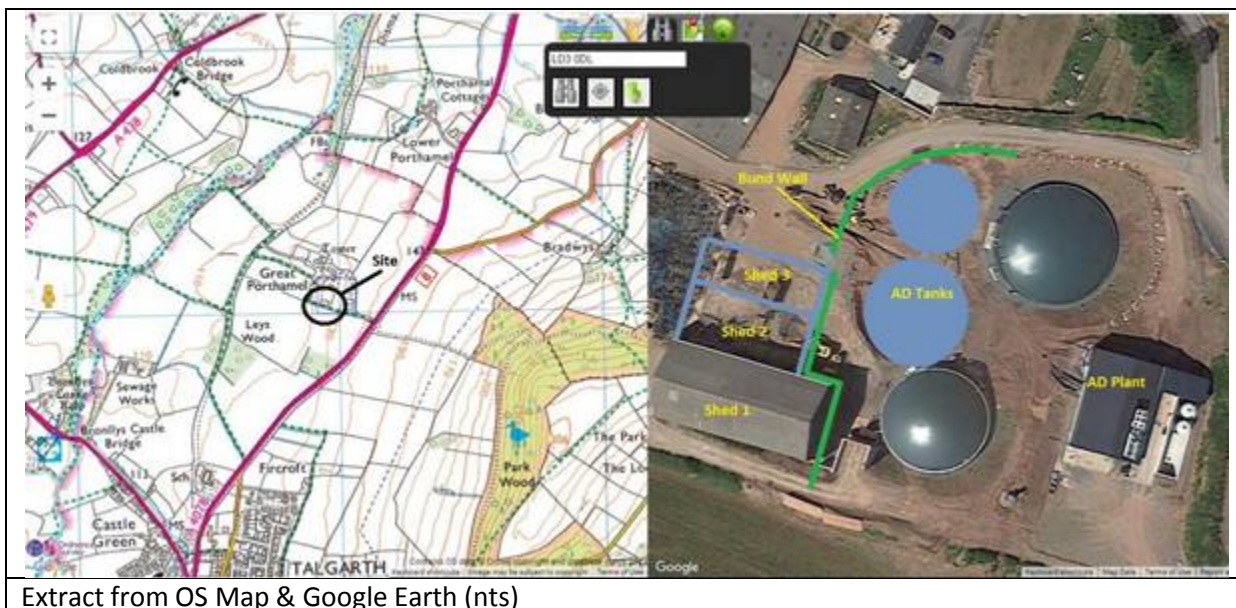
- Receive and review the client's as-built information for the existing AD bund walls and appurtenances;
- Check the structural stability of the bund walls under the hydrostatic load imposed by 2.05m of digestate;
- Recommend remedial works if necessary;
- Comment on the clamp's compliance with the Water Resources (Prevention of pollution) (Silage, Slurry and Agricultural Fuel Oil) Regulations 2010;
- Issue Structural Report

The report and investigation will be based on employer-supplied information, information supplied or reasonably inferred. Unless otherwise specified (and where applicable), it is assumed that the soil underlying the site forms a suitable, stable and competent foundation material and can support loads imposed by the works.

Normal services **excludes** variations and additional work, geotechnical testing, design of existing features, fire/acoustic/thermal performance, drainage/waterproofing design, fabrication details, reimbursable alterations, CDM services, project management, contract administration, obtaining of permissions and the like.

3.0 EMPLOYER-SUPPLIED INFORMATION

3.1 The site is as follows :-



3.2 Site Geology

Terra Firma (Wales) Ltd Geotechnical Report for the original AD Plant (Ref 1138 dated April 2011) indicates that the site is underlain by " ...firm, stiff, very stiff red brown slightly sandy CLAY with many gravels cobbles and sandstone lithorelics" derived from Raglan Mudstone.

While the AD tanks and AD plant have a recommended allowable bearing pressure of 500 kN/m² because these are founded on excavated bedrock. For the barn (sheds) where bedrock is deeper, an allowable bearing pressure of 100 kN/m² is recommended.

3.3 Documents

The client issued the following documents :-

Table 1 : Client-supplied Documents

DOCUMENT	DETAILS	REMARKS
Geotechnical Report 11338	Proposed Digester and Ancillary building and Tanks. Great Porthal Farm	Terra Firma (Wales) Ltd
Alpine Talgarth Top Survey 2D Rev A	Digital CAD drawing showing overall site survey	Used as basis for structural CAD plans
Alpine Surveys Datum reduction Vols	Volume retained for various liquid levels 123.75 to 124.75m	
Alpine Surveys TG/A3/02	Drawing showing max volume retained by bunds =2800m ³	Based on water level at top of wall 124.75mAMSL

3.4 Digestate banded level

The volume of digestate to be retained = 110% of the tank volume above ground level. The client indicated that this volume would result in a retained digestate level of 2.05m above ground level (ie 124.05m AMSL). This was checked based on Alpine Surveys' Datum reduction volumes table as follows :-

Table 2 : Estimated banded liquid level

CRITERION	TANK DG2	TANK DG3	REMARKS
D.1 =External tank diameter	28.927m	27.15m	From drawing
D.2= Internal Tank Diameter	27.983m	24.22	From survey calc
A= Internal tank area	615m ²	460.72m ²	$\pi D^2/2$
H= Height of liquid in tank above Gr. Lvl can escape to bund	2.7m	3.8m	Info from client and estimated fr. survey
V = Vol to be retained =1.10xAxH	1826 m ³	1925 m ³	
Banded Liquid Level mAMSL Above Gr. LVL	123.95 mAMSL 2.2m	124.05mAMSL 2.3m	Top wall= 124.75mASL Cf reported 2.05m OK

3.3 Observations & Client briefing

The Employer confirmed that bund wall posts and shed gable posts were 203x133x23UB with 0.8m deep x 1.3m long x 0.1.0 m wide foundations. Precast planks are 100mm thick pre-stressed concrete planks of C60 concrete

Site observations and briefing discussions with the client indicated that :-

Table 3 Bund wall observations

ELEMENT	DETAILS	REMARKS
Prestressed precast concrete planks	Thickness, h= 100mm (d=say 70mm) Height, b= 1000mm Span L = 570mm Concrete grade f _{cu} =60 N/mm ² Ultimate moment capacity = M _{cap} =0.156 f _{cu} x b x d ² = 45.86 kNm/m	Liquid load on bottom 1m plank, w <=10.5 kN/m ² γ _q = hydrostatic load factor=1.0 Ult applied moment to bottom plank Mu=γ _q w L ² / 8 = 27kNm/m (<M _{cap} OK)
Gate between corner column and reinforced concrete wall	Waterproof seals and clamped closer	
Shed 1 Gable Wall acting as bund walls	3x1000mm high x100mm thick precast concrete planks inside of 203x133UB gable columns @ 4.57m c/c with 1000wide x 1300 long x 800 deep base	Steel tabs position the planks at gable columns. Insufficient attachment
Shed 2 Gable wall acting as bund walls	3x1000mm high x100mm thick precast concrete planks within flanges of 203x133UB gable columns @ 4.57m c/c with 1000wide x 1300 long x 800 deep base	Columns at 4.57m c/c
New Shed 3 Gable wall acting as bund walls	-3x1000mm high x 100mm thick precast concrete planks located within gable columns @ 4.57m c/c - supported on column flanges and equal angles bolted to column webs	Columns at 4.57m c/c -
Gate at corner of Shed	Sealed clamped gate 1m wide supported on Shed 3 corner col & 254x133x25UB column	
Free standing bund wall 3m high (2 bays from gate to change in bunded floor level)	3x1000mm high x100mm thick precast concrete planks within flanges of 203x133UB gable columns @ 4.57m c/c with 1000wide x 1300 long x 800 deep base	Columns at 4.45m c/c
Free standing bund wall 2m high (10 bays pn curve at raised bunded floor level)	- 2x1000mm high x100mm thick precast concrete planks within flanges of 203x133UB gable columns @ 4.57m c/c with 1000wide x 1300 long x 800 deep base	Columns at 4.45m c/c

3.4 Silage Slurry Agricultural Fuel Oil (SSAFO) Regulations compliance

The Bunded area's compliance with the SSAFO Regulations is assessed in Table 3 as follows :-

Table 4 : SSAFO (Silage, slurry agricultural fuel oil) Rules

PARAMETER	VALUE	REMARKS
Exemption from rules	No	Constructed after 1991
Life span	>20 years	
Distance from water course	0m (Rainwater sump with valved outlet in bunded area)	<10m - FAILS unless modified to xxxx
Distance from protected water source used for human consumption, farm dairy, food preparation	500m	>50m from protected water supply source OK
Bund base - Impermeable base - Impermeable collector drain - Permeable joints between precast concrete planks and posts	-200mm reinf concrete surface bed to BS8110 (2m aprons) ??? Sikaflex mastic sealant	Impermeable OK ?? Consider providing 50mm wide over-banding bitumen tape over all joints
Bund Walls (Post & Plank) -Loads - Precast planks - Posts 203x133x25UB x3m high at 4.57m c/c -Joints between planks and posts	Triangular hydrostatic load 20.5kN/m ² at base to 0kN/m ² at 2.30m height - load capacity OK but to be confirmed -Excessive deflection and overstressed Sikaflex mastic sealant	-Loads to BS5502 See Table 3 See xxx Effectiveness unknown. Consider additional over-banding tape
Bund Area - Collector sump	54m ² x 1.65m deep sump in bunded area used for rainwater collection & re-use . Has two valves in series. Drain to river via pipes, grease traps and ditch only with permission-to-discharge after testing.	-Life >20 years OK - In bund so <10m from drain. - >500m from river - No discharge release ever carried out.
Silo (Tanks Total Capacity Silo (Tank single rupture Vo Lagoon Minimum capacity Effluent lagoon actual capacity	$\sim = 4 \times 3000 \text{ m}^3 = 12\,000 \text{ m}^3$ 1925 m ³ (see Table 2) $30 + 0.0127 \times (1925 - 1500) = 35 \text{ m}^3$ xxxm ³	>1500 m ³
Notify EA Form WQE4		Submit

4.0 STRUCTURAL STABILITY OF BUND WALLS, SHEDS & GRAIN CLAMPS

4.1 Design Codes of Practice

Design will be in terms of :-

- BS 6399 Part 1 : 1984 Dead & Imposed Loads
- BS 8110 Part 1 : 1985: Structural use of concrete
- BS 5950 Part 1 : 2000 : Structural use of steel

4.2 Soil/Silage Parameters

The site is reported to be underlain by firm slightly sandy CLAY with Raglan mudstone bedrock.

The bund posts and grain wall posts are concreted into the ground. These posts cannot be analysed as "pinned" or "fixed" foundations. They resist the cantilever loads by passive earth pressure over the buried depth. Structural analysis does not address geotechnical concepts so the conventional way of accommodating the passive earth pressure is in the form of a single parameter Winkler Soil Constant derived from the coefficient of sub-grade reaction which, in turn is derived from the allowable bearing capacity of the soil as follows :-

Table 4 Winkler Spring Constant Estimation

PARAMETER	VALUE	REMARKS
Foundation soil consistency	Firm	
Allowable bearing capacity, q.a	100 kN/m ²	Terra Firma (Wales) Ltd report
Settlement assumed in q.a formulation =d	25mm	Terzaghi
Factor of safety assumed in q.a , FoS	2	ditto
Modulus of Subgrade Reaction K _s =q.a x FoS / d	8000 kN/m ³	BOWLES JE
Tributary area of buried concrete encasement of post A = B x H	0.6m x 0.75m = 0.45m ²	
Winkler Spring Constant k.s = K.s x A	8000kN/m ³ x 0.45m ² =3360kN/m	BOWLES JE Use 3000kN/m for internal noded 1500 kN/m for edge nodes

Table 4 Load derivation for digestate liquid on bund walls

PARAMETER	VALUE	REMARKS
Farm Building Class (BS5502)	1	Load Factors as for BS 5950
Digestate Bulk density	10 kN/m ³	As water
Angle internal friction, ϕ	0°	"
Wall friction , δ	$\phi/3 < \delta < 2\phi/3$ Choose $\delta = 0^\circ$	WEBER RP <i>Retaining walls for non-geotechnical engineers</i>
Maximum earth height	2.05m	Client-specified
Horizontal Wind Load Windward Leeward	0.7 kN/m ² -0.217 kN/m ²	Not applicable to critical cases

Surcharge	0 kN/m ²	Not applicable
Height of water table in silage	Nil	

Silage/Grain pressure material properties are estimated in Table 5 as follows :-

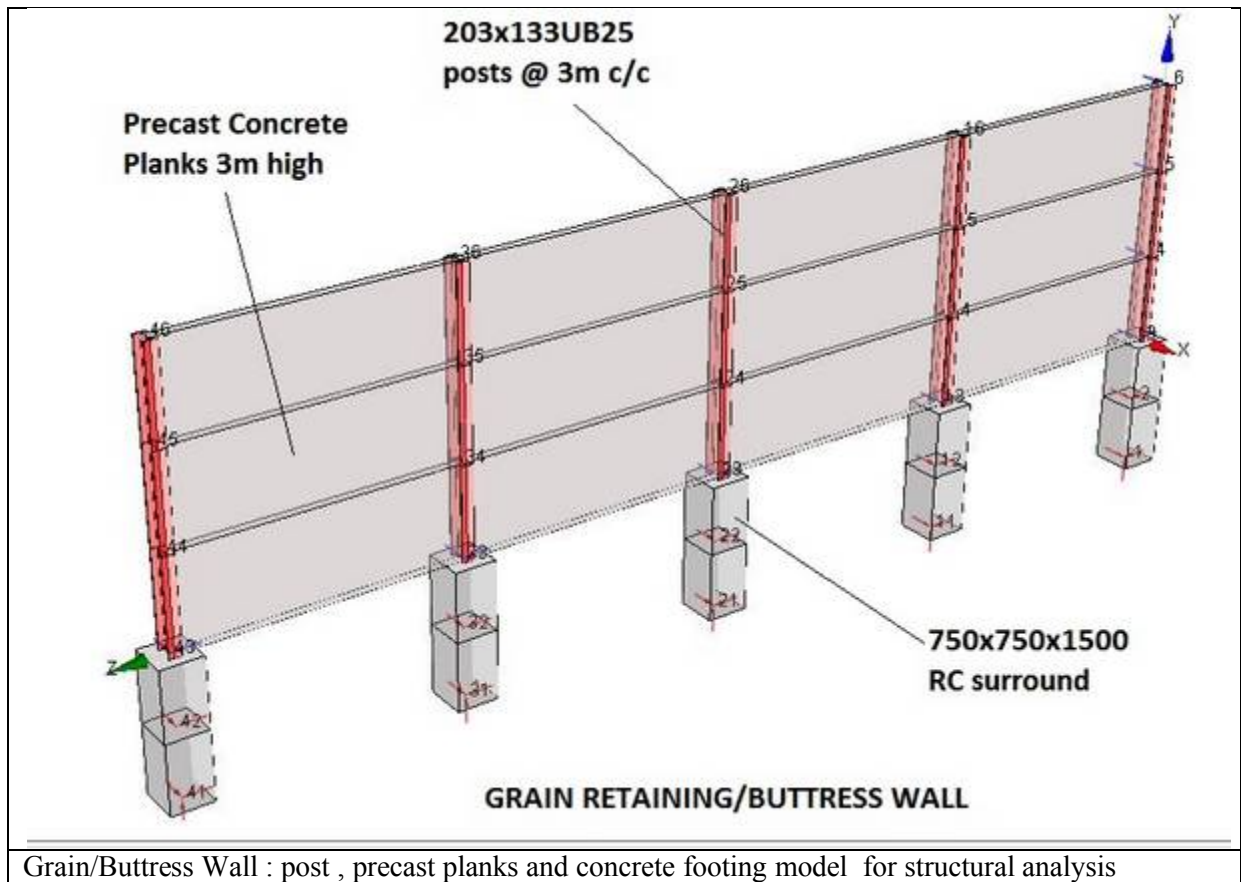
Table 5 Load derivation for Maize Grain Silage (on buttressing walls)

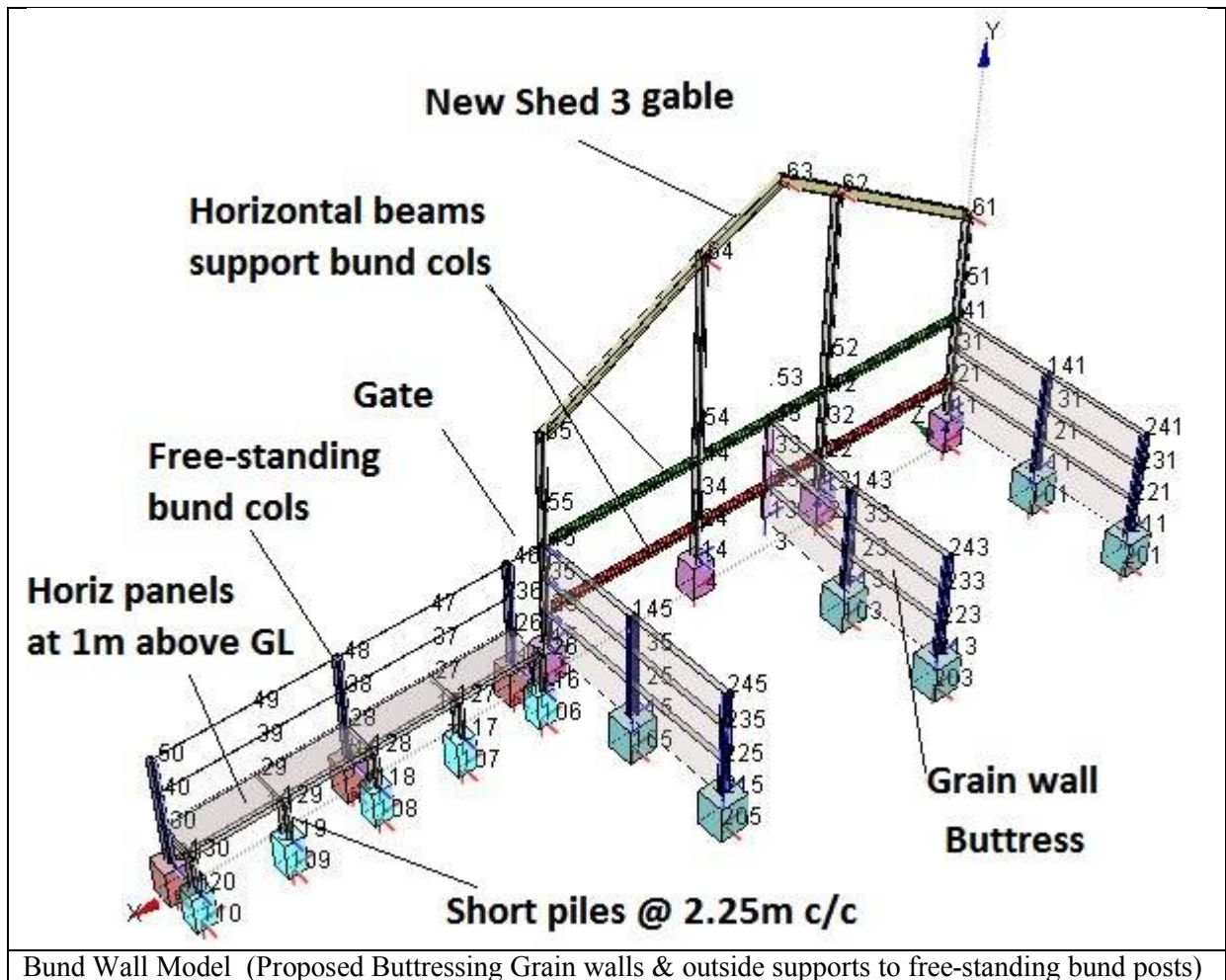
PARAMETER	VALUE	REMARKS
Farm Building Class (BS5502)	1	Load Factors as for BS 5950
Silage(Maize Grain) Bulk density Angle internal friction, ϕ Moisture Content	10.2 kN/m ³ 32° 60-70%	1040kg/m ³ <i>National Silo Association recommendations in BROWN & NIELSEN</i>
Wall friction, δ	$\phi/3 < \delta < 2\phi/3$ Choose $\delta = 20^\circ$	WEBER RP <i>Retaining walls for non-geotechnical engineers</i>
Maximum Silage Height Maximum Silage Slope	3.0m 25°	Client-specified
Horizontal Wind Load Windward Leeward	0.7 kN/m ² -0.217 kN/m ²	1324-Ayr-1
Surcharge on silage from tractor load	5 kN/m ²	Nominal
Height of water table in silage	Nil	
Maximum bearing pressure	100 kN/m ² static load	Conventional for medium-dense soil
Winkler Spring constant	300 kN/m	See xxx

The following design parameters are adopted for the retaining wall calculations:-

Table 6 : Retaining Wall Design Data

PARAMETER	VALUE	REMARKS
Farm Building Class (BS5502)	1	Load Factors as for BS 5950
ULS Dead Load Factor ULS Live Load Factor ULS Hydrostatic Load Factor	1.4 1.6 1.0	Concrete, Masonry & Soil Digestate
Design Pressure theory Pressure condition	Coulombe Active pressure	Utilizes wall friction Assumes wall moves > 0.01 H
Durability Exposure Conditions	- Moderate externally - Severe Internally	Corrosive silage juices
Wall height	3m	(3x1m high precast panels)
Post spacing	3m	203x133UB25 posts





4.3 Environmental & Local Authority Permissions

By others

5.0 STABILITY

5.1 Design Check Calculations

The design check calculations are shown on the attached calculations:-

Table 7 : Calculations

SHEET NO.	DETAILS	REMARKS
1541-C-01	Escaped digestate levels & loads on bund walls	Excell
1541-C-02	Unit loads on grain retaining/Buttruss walls	
1541-C-03	Subgrade reaction/Winkler soil spring constant	
1541-C-04	Brom's short pile additional restraint to free-standing bund posts in Cohesive soil	
1541-C-05	Brom's short pile additional restraint to free-standing bund posts in Granular Soil	
1541-H-01	HIT HY + V Chemical (Beams B3 + B4)	Hilti Profis
1541-H-02	HST3 M10 Gr 8.8 (Beam B3 + B4)	

1541-H-03 1541-H-04	HIT HY200 + V M10 Chemical (90x90x8EA) HST3 M10 8.8 (90x90x8 EA Grain wall to bund)	
1541 Sheds2-1	Analysis of 3 sheds with conventional, bund and grain loads	Prokon
1541 Sh-Steel-1	Check capacity of gables columns and beams to resist hydrostatic pressure on bund walls	Prokon
1541 Bund2-1	Analysis & design of sub-unit model of buttressed and free-standing bund walls	Prokon
1541 Grain-1	Analysis and design of single retaining wall supporting 3m of grain & surcharge on one side.	Prokon
1541 GUS-1	Design of gusset to connect prop to column	Prokon

5.2 Drawings

Explanatory drawings are included as follows:-

Table 8 : Drawings

SHEET NO.	DETAILS	REMARKS
1541-S-101	Existing (2-shed) Layout plan (1:250)	
1541-S-102	Existing (2 shed) plan and sections (1:200)	
1541-S-103	Proposed (3 shed) Roof Plan	
1541-S-104	Conceptual (3 shed) Ground Floor & Wall Plan	
1541-S-105	Proposed Long Sections	
1541-S-106	Details (incomplete - to follow)	

5.3 Results

The structural design checks are shown on the attached calculations and drawing. The results of design checks are summarized as follows :-

Table 9 : Summary of Results

ELEMENT	DETAILS	REMARKS
Existing precast concrete planks	Strength to be confirmed but compression moment of resistance OK for 2.3m digestate hydrostatic load	OK so far
Existing 203x102UB25 @ 4.57m c/c bund wall columns on shed gables (GCol1/2/3)	Fails in bending and overturning under 2.3m digestate hydrostativ load	FAILS so strengthening and buttressing required
Existing 203x102UB25 @ 4.57m c/c free-standing bund wall columns	Fails in bending and overturning under 2.3m digestate hydrostativ load	FAILS so strengthening required
Proposed Shed 3	Already constructed. Designed by others	Appears satisfactory

Grain retaining buttressing walls in Sheds 1, 2 & 3	-COL3: 203x133x25UB @ 3.0m c/c with min 750x750x1700 deep base. - 175mm thick precast concrete panels to fill space between flanges	OK
Horizontal Beams B1-B2 Shed 1 B2-B3 Shed 2 B4-B5 Shed 3	203x133x25UB on-flat spanning between corner cols & buttress walls With end plates to support on concrete & seated cleat supports on cols	OK
Free-standing bund cols 3m high @ 4.57m c/c	- install new 254x146x31UB short piers @ 2.285mc/c with 700x700x1300 bases and 1m exposed - Install 100x100x12 EA as supports for precast concrete planks -1000x4500x100 precast concrete planks supported on EQ's and short piles as propping to free-standing cols	To be agreed with client
Diagonal propping to shed corner cols	120x120x4 SHS with gusset connectors to mass concrete wall or steel cols	
Rainwater sump in Bunded area	2 x high pressure valves in series kept closed.	Probably OK to prevent digestate loss but requires NRW approval
Joints between precast planks and cols	Mastic	Probably OK to prevent digestate loss but consider over-banding for addition leakage resistance.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Existing Bund Wall Structural Stability

By calculation and observation, it is concluded that 110% of the discharge from any one digester tank at the GP Biotec AD facility at Great Porthamel will result in a maximum depth of digested to be stored in the bunded area.

By calculation, it is concluded that the existing bund walls will require strengthening to support the hydrostatic pressures resulting from bunded digestate

6.2 Proposed strengthening of bunding

Use horizontal beams to support gable bund columns spanning onto new grain-retaining buttressing walls as well as diagonal struts at corner columns in each shed .

Use horizontally laid precast concrete planks at 1m above ground level supported on short-piles at 2.285m c as props to the free-standing bund walls >2m height

6.3 **Other SSAFO aspects**

By observation and calculation, it is concluded that the bunding facility at Great Porthamel generally complies with the other (non-structural) aspects of the SSAFO Regulations. The wall panel joints could obtain additional leakage resistance by the addition of over-banding tape.

This Structural Report forms part of the CDM H&S File.

7.0 **CLOSURE**

I trust that this is satisfactory for your purposes. Please contact me if you have any queries.

Once you have fulfilled the terms of the Client/Consultant Agreement, I authorize you to issue this to the relevant Statutory Authority

Yours faithfully,

Gregory Cohen

GA Cohen
encl.

1541 Porthamel Bund Walls Report.doc