Broomfield Consultants

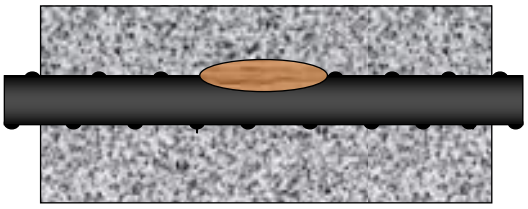
30B Vine Road,
East Molesey
Surrey KT8 9LF, UK

Tel/Fax +44 (0) 20 8941 6696
Mobile +44 (0) 77 11 00 6197

Email: johnpbroomfield@aol.com
johnpbroomfield@yahoo.co.uk
Website: www.jpbroomfield.co.uk

John P. Broomfield

DPhil, EurIng, CSci, FICorr, FIM^3, FNACE, FCS



Consulting Corrosion Engineer

Specialist in the Corrosion of Steel in Concrete

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Premier Cellars (UK) Durability and Watertightness

Report for:
Ross Burrell
Project Coordinator
Premier Cellars (UK)
Town Drove
Quadring
Spalding
Lincs PE11 4PU

PREMIER CELLAR COMPANY

Report JPB 161736 R2.0

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1. Executive Summary

There is a worldwide problem with leaking basements. Dr John Broomfield, an expert in concrete durability was asked by Premier Cellars (UK) Ltd (marketing brand Premier Cellar Company). to review their design for domestic substructures to show it meets the standards for a leak tight, durable structure.

The design of a steel tank with external reinforced concrete and a damp proof membrane provides a structure that consists of uncontaminated, well consolidated, well cured concrete protected by a DPM during construction and afterwards with an inner lining of steel.

The design, materials and construction methods meets the requirements of BS 8102, Eurocode 3 and BS 8500-1 to achieve a highly durable watertight substructure. The reinforced concrete should exceed 50 years life. The thickness of the steel tank alone should achieve a 100 year life in its own right according to the corrosion rate for aggressive soil over 100 years according to Eurocode 3.

I therefore consider that Premier Cellar Company have a design life of 100 years.

2. Introduction

John Broomfield of Broomfield Consultants was asked by Ross Burrell, to review the design and construction of their novel basement design with a view to achieving approval from building warranty providers such as LABC, NHBC and Premier for domestic basement/cellar applications.

Some correspondence had been exchanged with the building warranty companies which has specifically mentioned compliance with BS 8102 "Code of practice for protection of below ground structures against water from the ground."

This report reviews the design and construction of the Premier Cellar system with regard to achieving NHBC approval and with regard to BS 8102:2009.

Dr John Broomfield is a chartered engineer and chartered chemist; he is a fellow of the Institute of Materials, Metallurgy and Mining, the Institute of Corrosion, the Concrete Society and of the US National Association of Corrosion Engineers. He has over 40 years of experience dealing with durability of reinforced concrete. He has written two books on the subject and contributed chapters to five others. He has written over 100 articles and papers on the subject and chaired standard writing committees in Europe and the USA.

The problem of leaking basements and other underground substructures is universal. Dr Broomfield has helped both design durable leak proof reinforced concrete basements on large overseas infrastructure projects and dealt with the consequences of failures in the UK and internationally. In many of these cases, the problem has been failures of damp proof membranes.

3. Premier Cellar Company Design and Construction

Premier Cellar Company has co ownership with Premier Substructures and Premier Pits with the main group name being MBE Fabrications. They been have designing and installing their products for the commercial market since 1982. Projects range from simple car inspection pits to large commercial vehicle pits, railway inspection pits this led to Premier Substructures being set up. The demand from end users, engineers and main contractors wanting the watertightness, improved tolerances and speed on site the company evolved from inspection pits to selling and marketing bespoke structures in the ground for numerous reasons. These have been used in the past for baggage handling units, gym pits, large factory machinery sumps and seed storage units to name a few.

The basic design is a welded steel tank inside a reinforced concrete external lining with internal insulation and finishing. The tank is made of 6 to 8 mm mild steel plate with stiffening ribs.

The detailed design is carried out by an independent structural engineer to ensure there are suitable external rib reinforcement and external reinforced concrete for the size of the tank/basement and to take the loads of the above ground structure and hydrostatic pressures.

Welding of the steel structure is carried out in the manufacturer's facilities by personnel and procedures certificated to meet BS EN1090-2:2008 +A1:2011 to achieve water tight welds.

The excavation is lined with a 1000 gauge damp proof membrane cut to size with minimum 1000 mm overlaps.

Typical details are shown in Figure PC1 (attached). The process is carried out to a BS EN ISO 9001 quality management plan.

4. Installation Procedure

The construction process is to dig a suitably sized hole in the required location, 600 mm wider than the structure (depending on structural requirements), install the polyethylene damp proof membrane, insert the welded steel tank/Premier Cellar. The Premier Cellar is supported off RSJ's which are connected to the cellar. These RSJ are connected on to temporary/sacrificial concrete pad foundations and allow the structure to be suspended in the excavation to allow the correct pour of concrete around it.

The final step is to then pour concrete to fill the gap between the outside of the tank and the excavation wall and floor. The group has been installing structures like this for 35 years and have the experience to use the correct slump of concrete poured in the correct manor, poured in stages so that there is no issue with pressure lifting the Premier Cellar.

The basement is then complete, a beam and block or plank floor can then be placed on it and the house can be built on top of it.

5. Waterproofing to BS 8102:2009

BS 8102 "Code of practice for protection of below ground structures against water from the ground." Refers to:

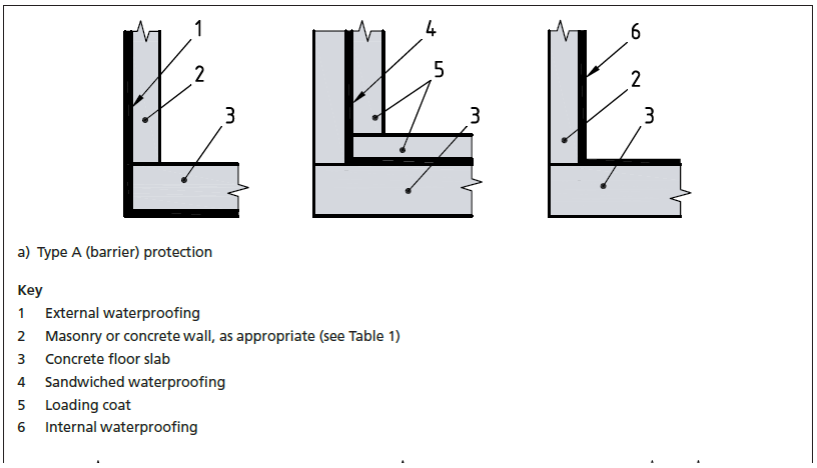
- Type A – Barrier Protection
- Type B – Structurally Integral Protection
- Type C – Drained protection

The Premier Cellar system can incorporate all three types but is primarily a Type B system where the welded steel tank provides full protection against water ingress. The external DPM also supplements the waterproofing. Welding of the steel tank is carried out in the manufacturer's facilities by personnel and procedures certificated to meet BS EN1090-2:2008 +A1:2011 to achieve water tight welds.

Figure 2 below is taken from BS8102: 2009 The Premier cellar system can be seen to be most similar to the 1st illustration in having an external DPM combined with the 3rd illustration where for Premier Substructures the internal waterproofing is a welded steel tank which requires no loading coats as in the 2nd illustration.

BS 8102:2009 BRITISH STANDARD

Figure 2 **Schematic illustrations of Type A, Type B and Type C waterproofing protection**



a) Type A (barrier) protection

Key
1 External waterproofing
2 Masonry or concrete wall, as appropriate (see Table 1)
3 Concrete floor slab
4 Sandwiched waterproofing
5 Loading coat
6 Internal waterproofing

BS 8102:2009 Section 9.3.3 is mainly concerned with steel sheet piles but states that where possible steel piles should be shop welded. This is similar to the case for the Premier Cellar, but is completed to code welding standards in a factory not site environment.

It can therefore be concluded that Premier Substructures meet and in fact exceed the requirements of BS 8102:2009.

6. Durability

The steel tank is protected from the groundwater by the external reinforced concrete. Concrete is an excellent protective coating to steel as it will prevent steel from corrosion in the presence of moisture and oxygen due to the alkalinity of the pore water. The protective properties of concrete to steel can be compromised by:

- Physical damage to the concrete – unlikely for a buried structure
- Chemical attack of the concrete – see below.
- Carbonation – does not occur below ground or in saturated conditions
- Chloride attack – most unlikely to suffer chloride ingress and even if it happens reinforcement will not corrode in water saturated, deoxygenated conditions which is what will occur in the concrete between the DPM and the steel tank.

BS EN 206-1 gives 3 exposure classes XA1, XA2 and XA3 for chemical attack of concrete from natural soil and groundwater lists the following as being the potential sources of aggressivity:

- Sulphates SO_4^{2-}
- Acidity pH
- Carbonates CO_2
- Ammonia NH_4^+

It is unlikely that high levels of any of these contaminants would be present at significant levels in a domestic housing situation. The DPM combined with the steel tank eliminate the hydraulic gradient. The external membrane combined with lack of hydraulic gradient will minimise ingress of contaminants into the concrete and therefore significantly hinder attack of the concrete. Even if the concrete is attacked, the attack must penetrate the full depth of the reinforced concrete before it reaches the steel tank.

The use of a zinc phosphate primer coating on the steel surface will protect the steel during shipping and installation and also enhances the protection provided by the alkalinity in the concrete.

The concrete is protected by the DPM which ensures the concrete is not contaminated by soil or groundwater ingress during construction and gives an excellent surface for the concrete to be cast against maximising the curing of the concrete by minimising water loss. The DPM on one side and the steel tank on the other also maximises the curing conditions for the concrete. The DPM will also minimise water ingress protecting the concrete from aggressive groundwater although it is unlikely that domestic housing will be built in aggressive groundwater locations.

The DPM also prevents exposure to flowing water and the steel tank prevents a hydraulic gradient from existing in the external concrete.

The first concrete pour is C30 120 slump or easy flow concrete to approx. 50mm above the floor. This self-consolidates under the steel base. Subsequent pour are C30 40/60 slump concrete to oversite level ready for beam and block and bricklayers to start. As there is no requirement for the concrete to be watertight, there is no need for construction

joints between pours to be watertight. The reinforcement will provide crack control but this is not essential for either durability or watertightness as that is provided by the steel tank.

The concretes used and the design exceed the requirements of BS 8500-1:2015 "Concrete – Complimentary British Standard to BS EN 206 Part 1: Method of specifying and guidance for the specifier" for a 50 year working life for buried reinforced concrete (Table A10).

In a worst case scenario where aggressive soil/water reaches the tank wall, it is a 6 mm steel sheet. Eurocode 3 states that for steel piles in aggressive soil for a 100 year life the maximum corrosion rate is 0.06 mm/year/side. It will therefore take 100 years for the corrosion to penetrate a 6 mm steel tank wall.

As it will take several decades for the contaminants to reach the tank steel surface before corrosion can initiate, we can confidently expect a 100 year design life from Premier Cellar Company.

7. Concluding remarks

7.1 The Premier Brand – Premier Pits and Premier Substructures design and construction process is well proven with 35 years of case histories.

7.2 The design and construction process provides a watertight substructure that conforms to BS 8102 using certificated welders and an ISO 9001 quality management system to achieve watertight seals between the steel plates making up the tank.

7.3 The concrete casting methodology, the concretes used and the "sandwich" of DPM, concrete and steel tank ensures the concrete self-consolidates, is extremely well cured and has maximum crack control.

7.4 The concretes used and the design exceed the requirements of BS 8500-1:2015 "Concrete – Complimentary British Standard to BS EN 206 Part 1: Method of specifying and guidance for the specifier" for a 50 year working life for buried reinforced concrete.

7.5 Using the corrosion rates in Eurocode 3 for steel piles in aggressive soil, the tank alone, without the DPM and concrete should last 100 years before corrosion breaks through.

7.6 Premier Cellar Company should therefore exceed a 100 year design life as basement/cellar structures in domestic houses.