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INITIAL GROUND GAS ARTICLE FOR TBIC DISCUSSION on 7.12.16

With the intervention of third party warranty providers in structural waterproofing design, the identification of ground contaminants and naturally occurring ground gases has risen in prominence. We will all be aware of recent instances where architects or developers have contacted us for advice on how to discharge outline planning conditions and ground gas protection precautions in conjunction with our structural waterproofing advice. Likely as not, we have all consulted relevant codes of practice pertinent to ground gas protection and scratched our heads at the apparent complexity of the subject, whist trying to reconcile all this with a BS8102 2009 compliant waterproofing design which is applicable to all project constraints. It is the case that traditionally, ground gas protection and structural waterproofing design have inhabited separate orbits in the universe of construction technology. By force of necessity driven by a growing demand in the industry for complimentary or even totally integrated solutions to address both, this is about to change. Things are constantly evolving so the purpose of this short article is not to solve these problems, but to begin a thought process and to provoke discussion so that we begin to at least identify the issues, and only then can we begin to find solutions.

Radon, Methane, CO2, VOC's and even Mercury. These are the gases that have been highlighted as potential threats to human health on basement sites in various enquiries which I have received. Research into such gases and mitigation measures leads you inevitable to consult with BS8485 2015 and Ciria C735, which are the two main standards for gas protection measures and verification standards in the industry.

It soon becomes apparent that far from simply specifying a "gas membrane" to protect structures against ground gas ingress, there is a complex matrix of variables which must be taken into account to arrive at a gas protection proposal which in turn may be subject to scrutiny by a client-appointed third party environmental consultancy which may well have been involved at the GSV stage (gas screening value site survey – boreholes and monitoring) and/or the desk study to arrive at a theoretical "CS value"/threat level. This is not necessarily a bad thing, because we are waterproofing experts, not ground gas experts and submitting our proposals for consideration and approval by third party "experts" employed by the client for that purpose must by definition act to mitigate our liability for the ground gas mitigation aspects of the design. Likewise, if a verification (on site testing) process is required to prove the integrity of the installed ground gas measures then this will need to be undertaken by a third party independent company with no commercial interest.

With all the above in mind my instinct when making gas mitigation proposals (a bit like when I have submitted full plans building regulations applications in the past) is to seek the advice of the "experts" who will be involved first, before making a submission, so that no time is wasted with solutions that will not pass, to establish that the client will be establishing a network of third party expert consultancy who can subject my proposal to scrutiny, always to make reference to BS8485 guidance tables (in the same way that I refer to BS8102 2009 when making a case for a structural waterproofing solution), to make a logical step by step argument which explains the various "layers" of protection clearly and to devolve design liability as much as possible into the realm of the established gas protection industry experts who will be involved in the project.

In summary, the various "layers" of gas protection I am referring to, as defined in BS8485 2015 are: Ventilation, Structure, Gas Protection membrane. Without getting too technical, to arrive at a logical design solution you need to balance these three mitigation tools against the Building Type (there are A,B,C,D,E etc categories for residential, commercial, industrial buildings etc) and then to balance these against the type of gases that have been found to be present or potentially present in the site, and then to balance these against the CS Value of 1-6 (the GSV screening determines the CS Value) that has been determined for the site. You get "points" awarded for various types of membrane, structure and ventilation, and you need to hit a certain points overall "points" score that is a composite of measures and that has usually been pre-determined by the consultancy that determined the CS value. See below the BS8485 points system.

BS8485 GAS PROTECTION SCORES – STRUCTURE, MEMBRANE AND VENTILATION

Table 5 – Gas Protection Scores for Structural Barrier

Floor and substructure design	Score [1]
Precast suspended segmental subfloor (i.e. beam and block)	0
Cast in situ ground-bearing floor slab (with only nominal mesh reinforcement)	0.5
Cast in situ monolithic reinforced ground bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations	1 or 1.5 [2]
Basement floor and walls conforming to BS 8102:2009, Grade 2 waterproofing [3]	2
Basement floor and walls conforming to BS 8102:2009, Grade 3 waterproofing [3]	2.5

Notes: 1Scores are conditional on breaches of floor slabs, etc., being effectively sealed. 2To achieve a score of 1.5 the raft or suspended slab should be well reinforced to control cracking and have minimal penetrations cast in. 3The score is conditional on the waterproofing not being based on the use of a geosynthetic clay liner waterproofing product.

Table 6 – Gas Protection Scores for Ventilation Protection Measures

Protection element/system	Score
Pressure relief pathway (usually formed of low fines gravel or with a thin geocomposite blanket or strips terminating in a gravel trench external to the building)	0.5
Passive sub floor dispersal layer: Very good performance: Good preformation:	 2.5 1.5
Active dispersal layer, usually comprising fans with active abstraction (suction) from a subfloor dilution layer, with roof level vents. The dilution layer may comprise a clear void or be formed of geocomposite or polystyrene void formers	1.5 to 2.5
Active positive pressurization by the creation of a blanket of external fresh air beneath the building floor slab by pumps supplying air to points across the central footprint of the building into a permeable layer, usually formed of a thin geocomposite blanket.	1.5 to 2.5
Ventilated car park (floor slab of occupied part of the building under consideration is underlain by a basement or undercroft car park)	4

Table 7 – Gas Protection Scores for the Gas Resistant Membrane

Protection element/system	Score
Gas resistant membrane meeting all of the following criteria: • sufficiently impervious to the gases with a methane gas transmission rate <40.0 ml/day/m2/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method); • sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas • emissions; • sufficiently strong to withstand in-service stresses (e.g. settlement if placed below a floor slab); • sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc); • capable, after installation, of providing a complete barrier to the entry of the relevant	2

Protection element/system	Score
gas; and • verified in accordance with CIRIA C735 [N1]	

Note that a "Gas Resistant Membrane" is defined as being "sufficiently impervious to the gases with a methane gas transmission rate less that 40 ml/m2/atm (average) for sheets and joints (tested in accordance with BS ISO 15105-1 Manometric method)".

Note that the gas resistant membrane needs to be verified in accordance with CIRIA C735 (there are third party gas membrane verification companies that can do this).

Note also the excerpts below:

Basement floor and walls conforming to BS 8102:2009, Grade 2 waterproofing [3]	2
Basement floor and walls conforming to BS 8102:2009, Grade 3 waterproofing [3]	2.5

This is interesting because as we know, Grade II and Grade III waterproofing both inhibit the penetration of liquid water into the internal occupied spaces of a structure but it does not necessarily mean the structure is watertight (take Type C Cavity Drainage for example where penetrating ground water is merely controlled and managed by HDPE cavity drainage membranes that may not have passed the 40 ml/m2/atm (average) test) so even in a "BS8102 Grade III Waterproofing" structure, we could have a situation where gas can permeate through the structure and through the cavity drainage membranes lining it and into the occupied environments. This I think points more to a misunderstanding of BS8102 2009 by the authors of BS8485 2015, so I simply take the structural resistance to ground gas to be of Type A or Type B waterproofing which in any case, is more commonly integrated with Type C as part of the now standard "Combined Waterproofing" approach now advocated by third party warranty providers.

Of greater note perhaps is that BS8485 includes reference to BS8102 2009 highlighting basement forms of construction from a gas resisting point of view, Grades 1, 2 and 3, and advocates external tanking above all else in addition to reinforced concrete construction. It also says that Type C systems can be pose an "unacceptable risk" from a ground gas point of view because of the tendency for ground water to contain organic compounds which can contain organic compounds which can then degrade to form methane or carbon dioxide.

Excerpt from BS8485 2015:

Forms of construction with the potential for large numbers of joints (e.g. piled walls and insulated concrete form systems) can be more prone to leakage unless great care is taken during construction and, ideally, are to be avoided on high gas risk sites if possible. Basements using Type C protection (i.e. drained cavities) might pose an unacceptably high risk on sites affected by ground gas. Infiltrating water might contain dissolved gas and/or contain organic compounds that can degrade to form methane and/or carbon dioxide.

Also note that many of the gas proof membranes (eg. foil interlayer membranes) that pass the BS8485 benchmark 40ml/m2/day permeability test are not certified to resist hydrostatic pressure so cannot theoretically be used in basement structures. Nor can sub slab ventilation, radon sumps (for obvious reasons) and many basements are "inaccessible" from outside due to piling or underpinning.

Perhaps we should also note the following excerpt from BS8485 when we consider the installation of electrically powered fan means of actively negatively or positively pressurising the drainage space behind the cavity drainage membranes:

B.3.2 Active systems

B.3.2.1 General

Active systems involve air pumps and need an electrical power supply; these should not be specified for private residential buildings but can be used for managed buildings, although they are less preferable than passive systems and are also less sustainable.

In other words, systems that rely upon electrical fans to work as part of the gas protection measures cannot be used in private residential dwellings. They can be used in commercial buildings where there are management companies etc set up to run them, but their use overall is generally discouraged by BS8485 2015.

It is also worth noting that where systems are positively pressured behind the cavity drainage membranes then apertures such as a continuous condensation strip around the base of the membrane left open to intercept surface condensation forming upon it will need to be sealed which results in a conflict of interest between the perceived need to have a condensation strip in the first place and the need to have the membrane hermetically sealed to maintain the positive pressure zone behind it. Likewise, the implications of vents through the membrane in negatively pressured systems should be considered.

Another grey area I have identified to do with vented cavity drainage based systems is whether or not is acceptable to use an HDPE cavity drainage membrane at all (positive or negative) because as far as I know from my discussions with the ground gas industry, HDPE cavity drainage membranes would not pass the benchmark 40ml/m2 per day at average atmospheric pressure test which is the pre-requisite of compliance with BS8485 2015. And neither for that matter, do many of the gas membranes currently in circulation. Therefore, how can we responsibly use them in the control of dangerous ground gases?

Conclusions

I have tried to keep this article to maximum four pages of A4 to encourage people to read it all. The holy grail would be to marry basement waterproofing to ground gas proofing and to have one system which does it all. However, there is much variation in basement structure types and project constraints and there are also many variables within the BS8102 2009 and BS8485 2015 which leads to composite approaches involving Structure, Ventilation, Barrier Membranes, and Grades of Environment. Designing on a “case by case” basis is therefore recommended and taking the time to set out your design rationale for the benefit of third party consultants is essential. I would not personally embark upon a gas resisting design that was not subject to third party scrutiny at the design stage because of the risk of failing to comply with what can be a technical and sometimes contradictory gas protection market which is saturated with consultants who are far more qualified in this particular industry than we are. I have heard of projects where thousands of square metres of “gas protection” have had to be ripped out of buildings because the design was none compliant so slowly, assuredly and cautiously would be my mantra in these early stages.

There are of course many other aspects of BS8485 2015 and the similarities and differences it bears in relation to BS8102 2009 but these can be unearthed and discussed in following debates.

The purpose of this short article was to open an initial discussion and in this, I hope it has succeeded.