Latest developments in ground gas and vapour assessment

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The next 20 minutes

- Latest developments in ground gas and vapour assessment

- How to make a more robust assessment of low risk sites using BS8485 “TOC” approach
- The myth of “worst case” gas conditions and misconceptions
- When is TOC approach appropriate?
- TOC approach and BS8485: 2015
- Lessons learnt applying the method

- CIRIA C748 on VOC membranes

Background to TOC - CLAIRE RB17

- Recognition that number of gas monitoring wells is limited on most low risk sites
- Limitations of gas monitoring – influence of groundwater, etc on flow rates and concentrations
- With a robust conceptual model and understanding of gas generation in natural soils it is possible to assess risk without gas monitoring
- Can obtain much greater number of TOC samples to robustly characterise Made Ground
- Far more robust than gas monitoring on low risk sites – providing the method is used correctly

Myth of “worst case” conditions

- Worse case gas concentration occurs at point of generation
- 55% CH_4 and 45% CO_2 (or thereabouts)
- In low risk sources this occurs due to localised anaerobic microsites that develop in an otherwise aerobic mass of soil
- Monitoring in source (even continuous monitoring) will often not give “worst case conditions” – if methane is being generated and do not have 55%/45%, not monitoring worst case
- Need to understand how much gas can be generated to understand worst case conditions
- Wells in migration pathway outside a source is where use of gas monitoring is appropriate to identify worst case conditions

When is TOC approach suitable?

- When CSM indicates very low to moderate potential gas hazard (ie a lot of sites) and source is below site

D.3 Application

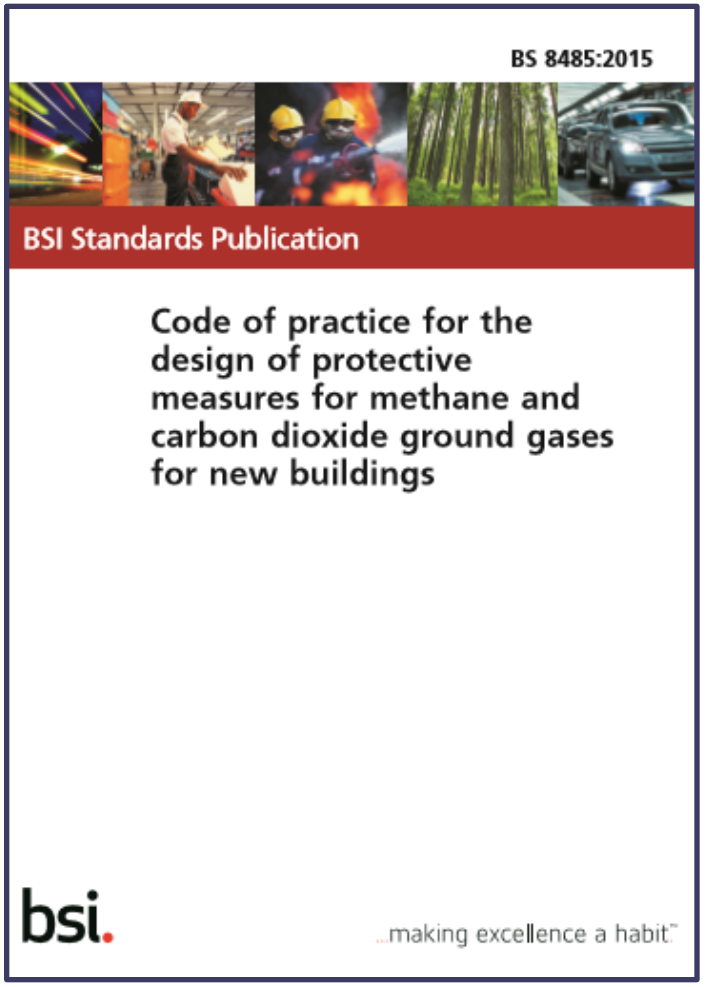
This approach may be adopted if:

- the preliminary conceptual site model has not identified any high gas generation sources; and
- the source is made ground that has less than 3 m average depth and 5 m maximum depth, and with TOC less than the limit for CS3 in Table D.1.

- BS says it cannot be applied retrospectively – but it can help with DQRA and override GSV approach

How to use the RB17 or TOC method

- Method is summarised in Appendix D of BS8485: 2015
- Develop a robust CSM
- Site investigation to include TOC data and forensic description of materials
- Sufficient to characterise the source
- Comprehensive descriptions of soils in trial pits including visual assessment of proportion of degradable materials (eg 5% wood, 10% paper, 1% green waste, etc)



Credible sources and pathways

- **Credible** sources – eg if a landfill is 200m away on the opposite side of a valley it is really likely to be a credible source?
- **Credible** pathways – Peat and Aluvium are often low permeability – can gas really migrate out of the ground quickly?

Has any of the following been identified:

Credible sources and pathways for landfill gas migration from an off site landfill or mine workings Whether a pathway is credible depends on distance, topography, nature of landfill (eg lining) or workings and geology. This must be demonstrated by a robust conceptual model.

Site has been a registered landfill site (This does not include general Made Ground with occasional objects such as pieces of wood) or are there mine openings nearby.

Made Ground max depth > 5m or average depth > 3m?

Representative TOC results from Made Ground exceed maximum values for CS3 given in Table 2.

Three possible conclusions

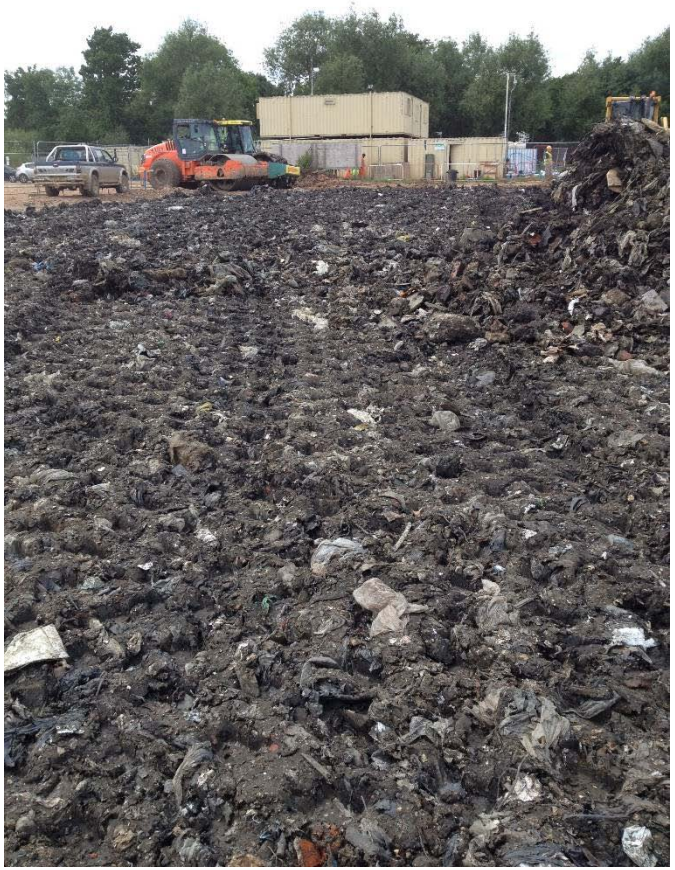
1. Gas monitoring not necessary and specific protection measures not required

2. Gas monitoring not necessary but protection measures required – determine using TOC content of source. Only reason for gas monitoring is to remove need for protection eg where source of gas is Alluvium

3. Gas monitoring required

Testing and analysis

- Forensic examination of Made Ground – procedure in BS8485
- It is being offered as a service by labs
- TOC testing on fine soil fraction (<10mm) – BS EN 13137
- It is not expensive to get a lot of TOC tests completed
- Do not skimp on this – the more data you have the better



TOC Limits

BS 8485:2015 **BRITISH STANDARD**

Table D.1 **Limiting values of thickness and organic content of made ground (after RB17 [1], Table 1)**

Thickness of made ground	Maximum total organic carbon content of made ground – TOC		Site characteristic situation (CS) to be assumed
	Made ground in place for <20 years	Made ground in place for >20 years	
m	%	%	
Maximum 5 m Average <3 m	≤1.0	≤1.0	CS1
Maximum 5 m Average <3 m	≤1.5	≤3	CS2
Maximum 5 m Average <3 m	≤4	≤6	CS3

NOTE Gas monitoring is required where TOC is greater than 4% (or 6% in old made ground). Gas monitoring results show whether the high TOC is available or not and if existing conditions are generating ground gas.

Managing earthworks using TOC

- Excavated an old industrial landfill
- Processed materials into streams
- Manufactured fill to be placed below development platforms and landscaped areas
- Meet geotechnical, environmental and gas requirements

Managing Earthworks

- Used TOC criteria (amongst others) to manage materials that could be re-used on site.
- Part of comprehensive earthworks specification developed in conjunction with the contractor (Vertase FLI)
- Gas generation tests on material – bespoke test specification and analysis developed by EPG
- Extensive bespoke monitoring of wells and surface emission surveys using various methods
- Understanding groundwater chemistry and Redox
- Robust analysis of results

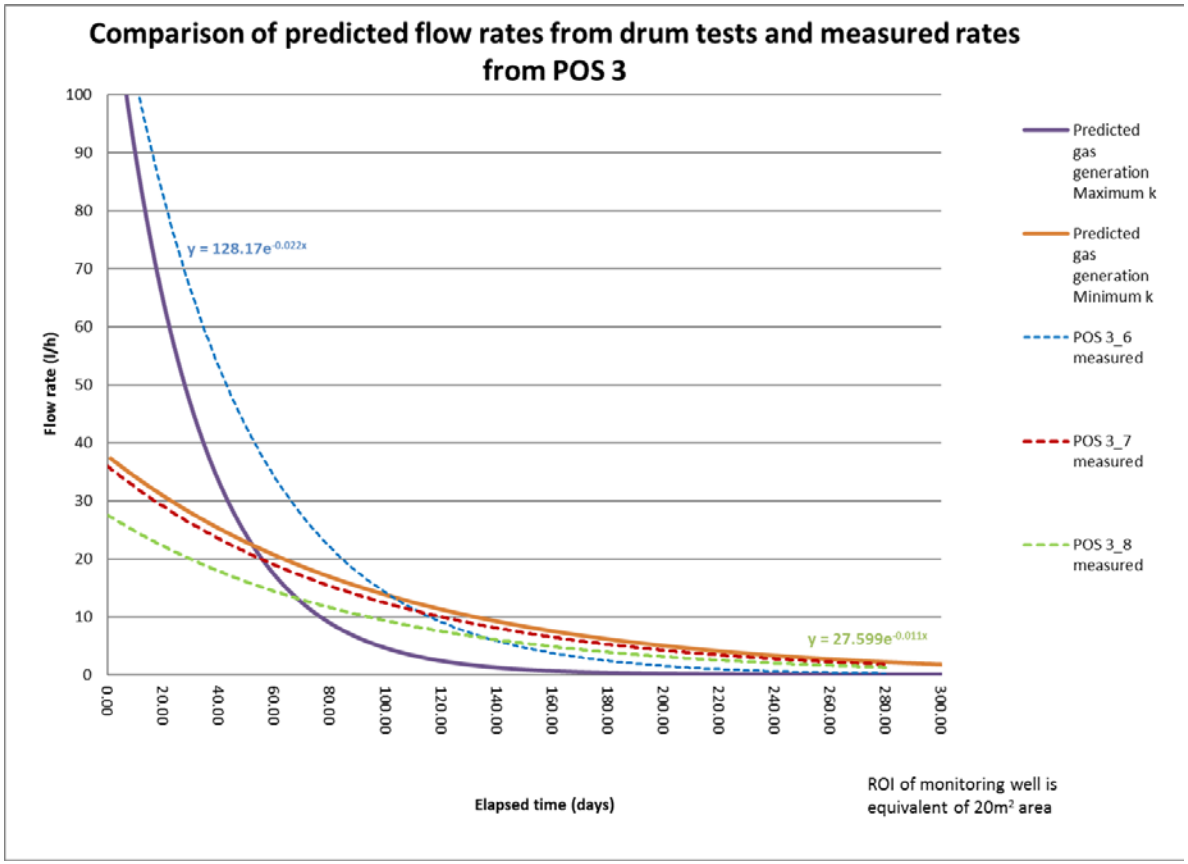
Compliance testing

- Extensive compliance testing
- Including TOC and segregation tests
- Main aim was to manage the material to limit gas potential before it was placed rather than rely on post construction gas monitoring (which is too late!)

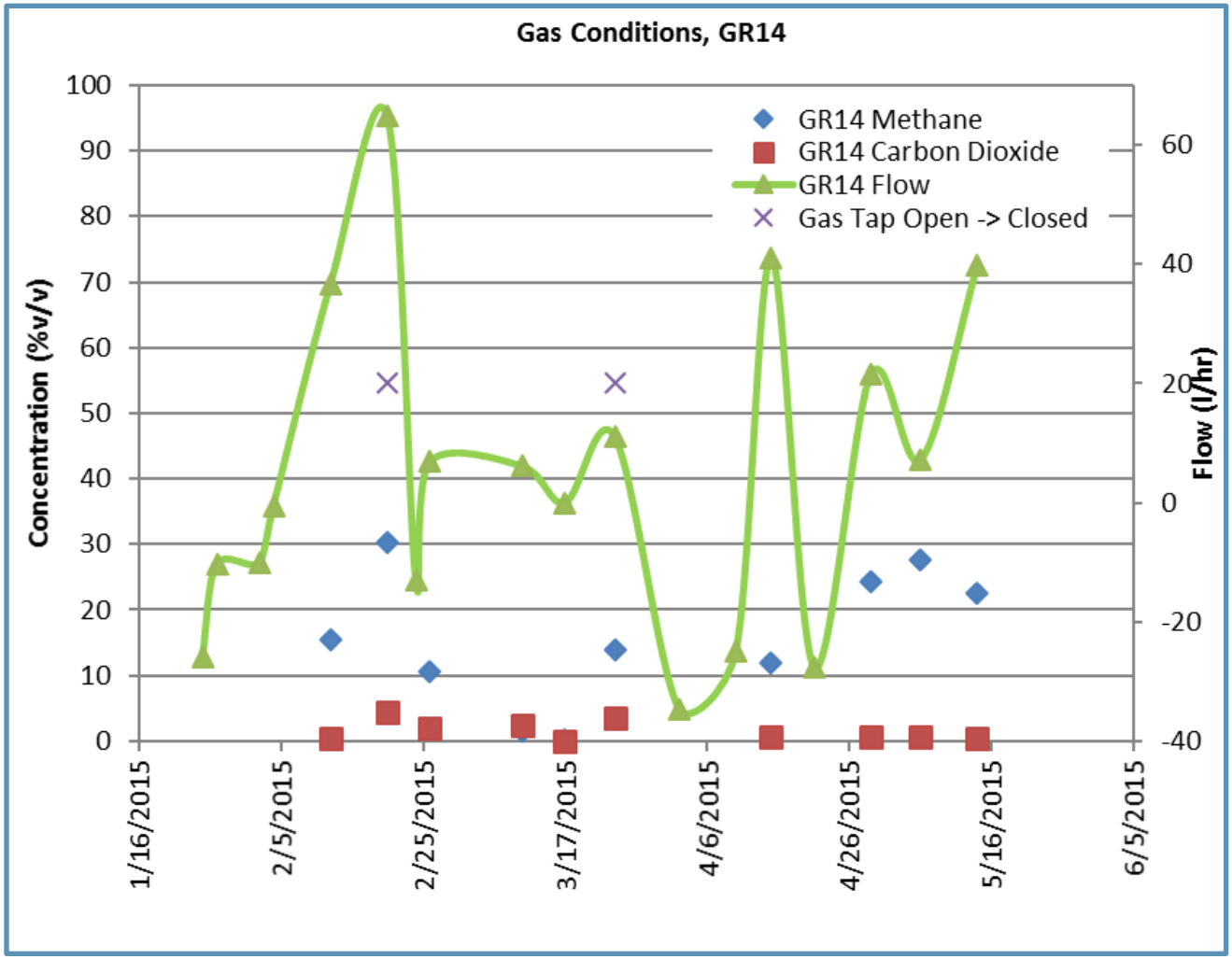
- It is not easy!

Correlation of borehole data with gas generation tests

- Settlement and compaction influenced flow rates

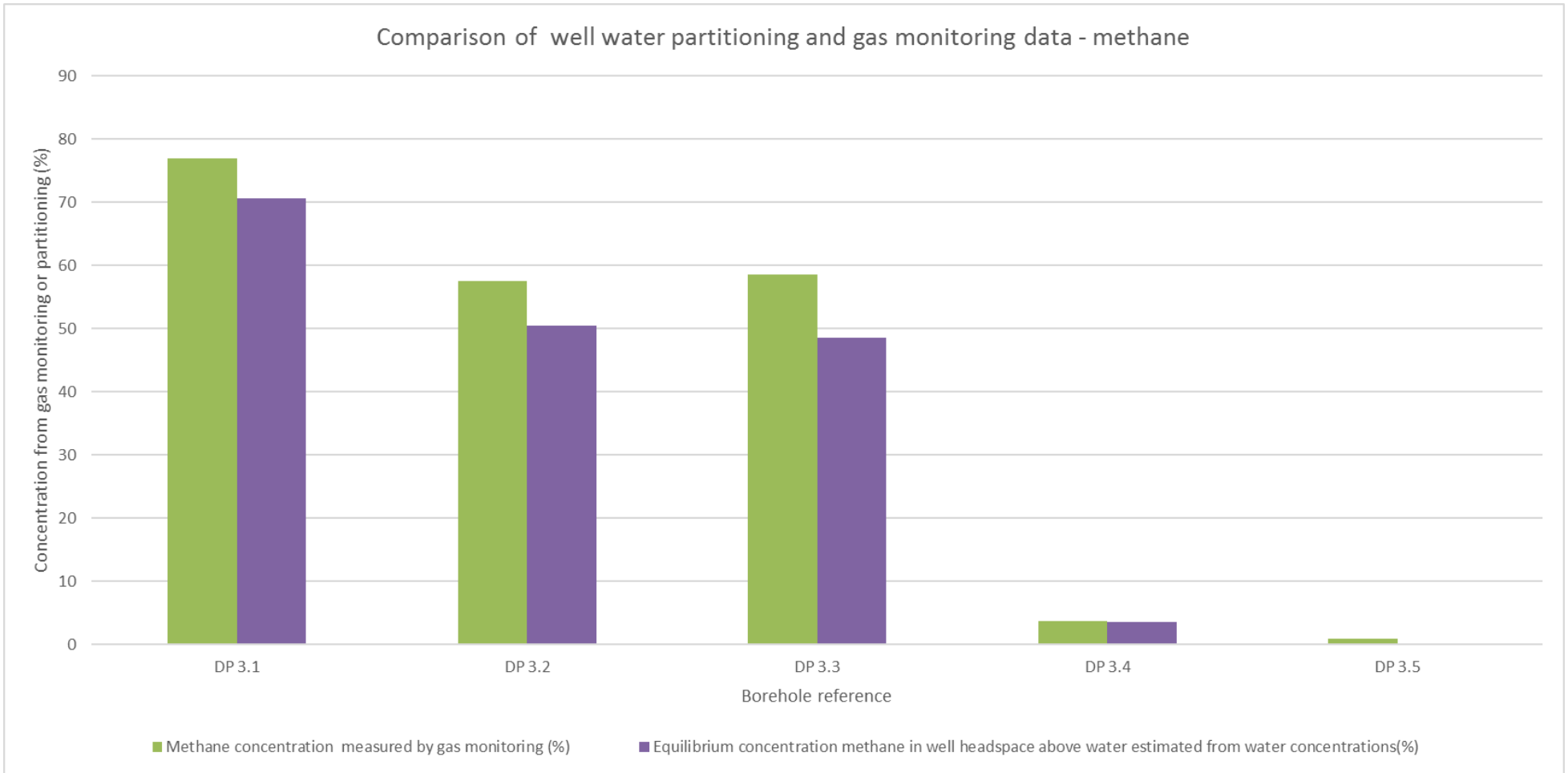


Measuring borehole flow rates



Groundwater monitoring

- Wells that are dry have no gas

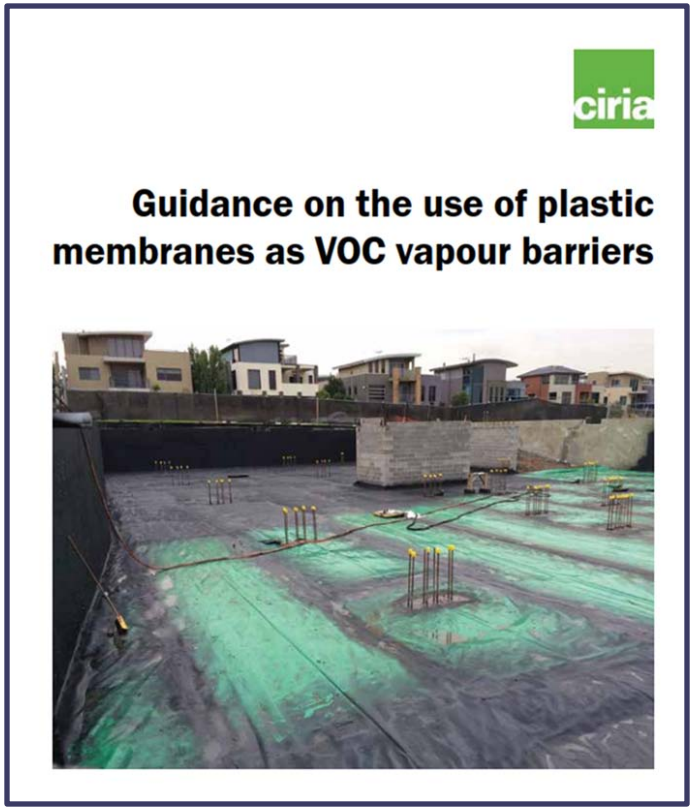


What we have learnt recently

- If well is installed in gas source, most variations with atmospheric pressure are caused by ebb and flow of atmospheric air into the well through the soil
- Gas monitoring often not a good indicator of risk
- Reservoir of gas at bottom of air mixing zone in surrounding soil can unduly influence results in well
- Gas taps on wells should be left permanently open to obtain a true indication of the gas regime
- Monitor and record flow rates and concentrations for extended periods at every visit

C748 VOC barriers - key points

- How VOCs migrate through membranes
- Test methods to determine rate of permeation of VOCs
- Test methods to determine durability when exposed to VOCs
- Risk assessment taking account of the presence of a membrane
- Specification of membranes for VOC permeation (many of the factors are also relevant to methane and carbon dioxide)



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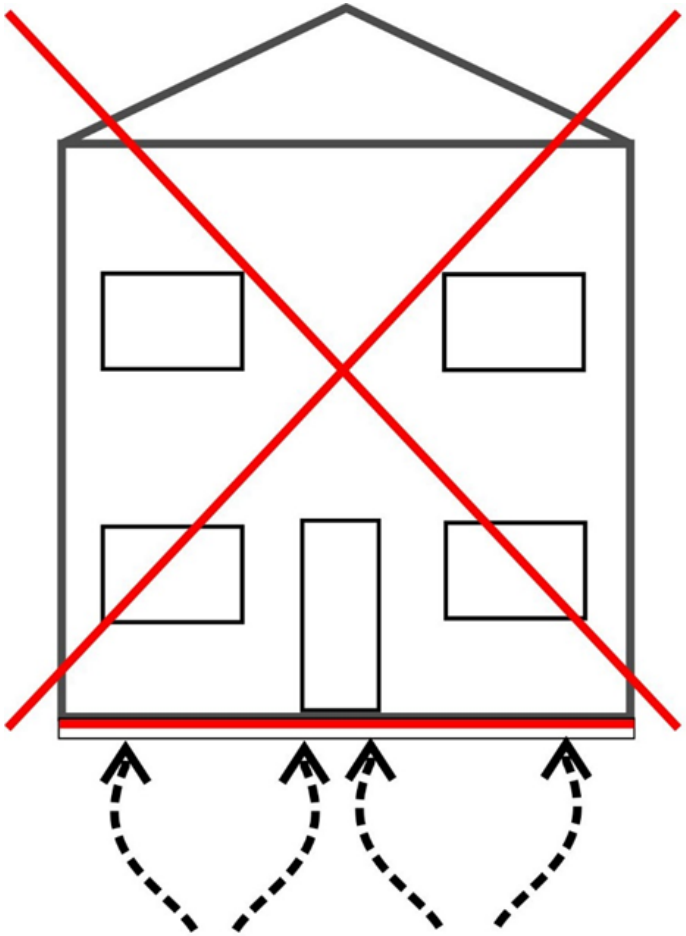
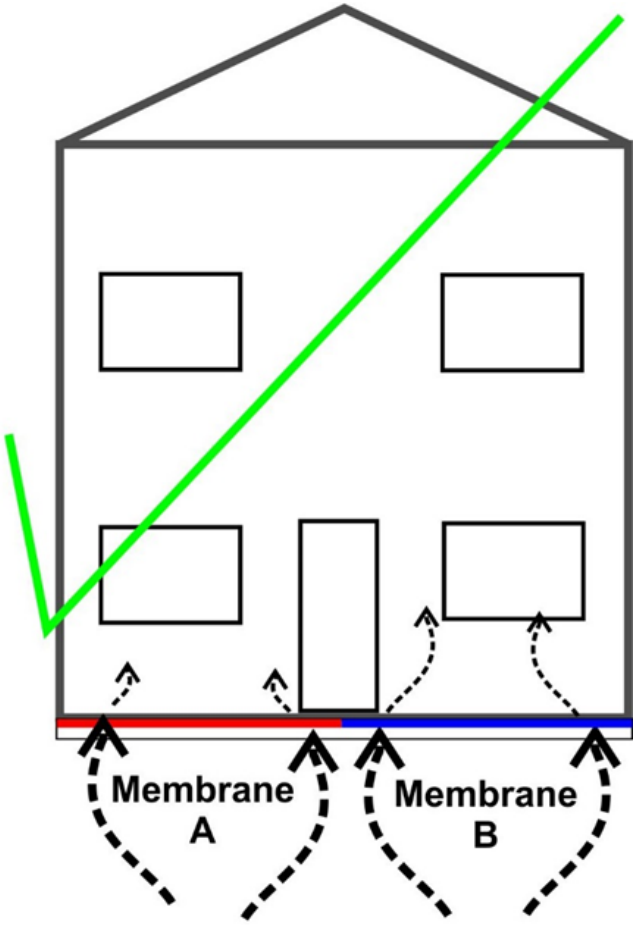


Has been common to assume that any membrane automatically breaks the vapour migration pathway

This is not correct



Membranes inhibit the vapour migration pathway

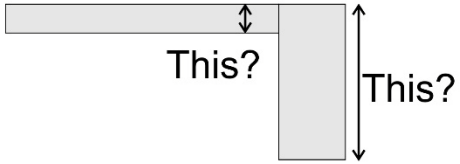
The extent that ingress is reduced depends on the nature of the membrane and the VOCs present

The CSM for vapour – what are you modelling?

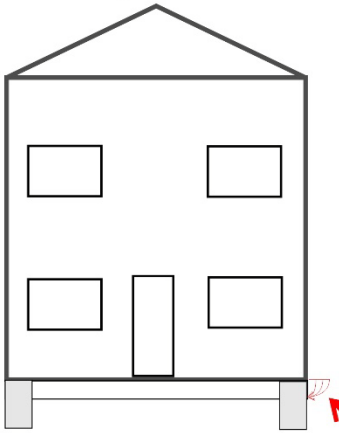
CLEA

What do you think you are modelling?

Foundation thickness?



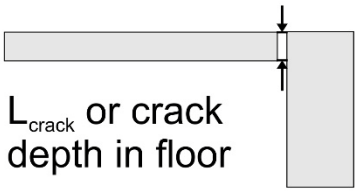
Height of living space below ground level?



CLEA uses a default value for air ingress unless you tell it not to - 25 cm^3/s

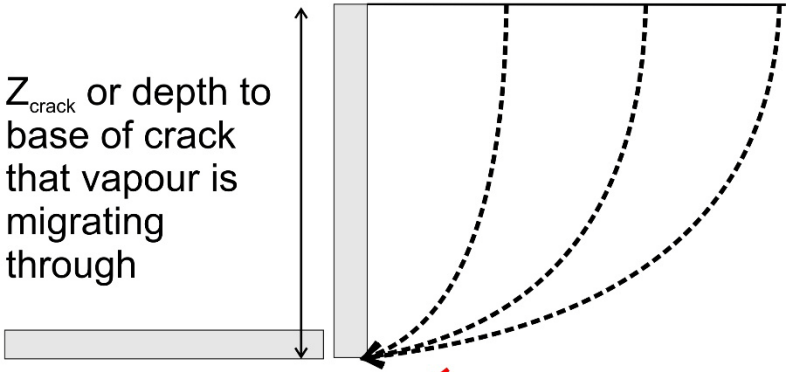
J & E

What you are really modelling?



L_{crack} or crack depth in floor

Is default for L_{crack} of 0.15m applicable to your site?



Z_{crack} or depth to base of crack that vapour is migrating through

No basement then $H_{cellar} = 0$

$Z_{crack} = H_{cellar} + L_{crack}$

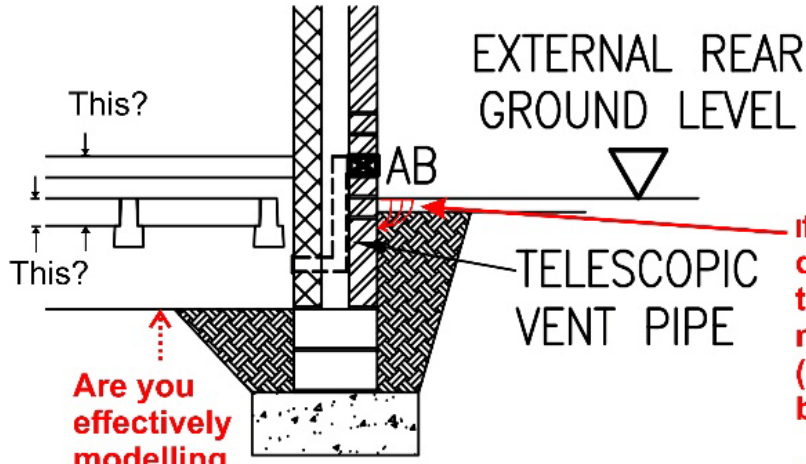
Application to an actual floor slab/foundation design block and

L_{crack} or crack depth in floor slab

Depth of block only?

Depth of block plus insulation plus screed?

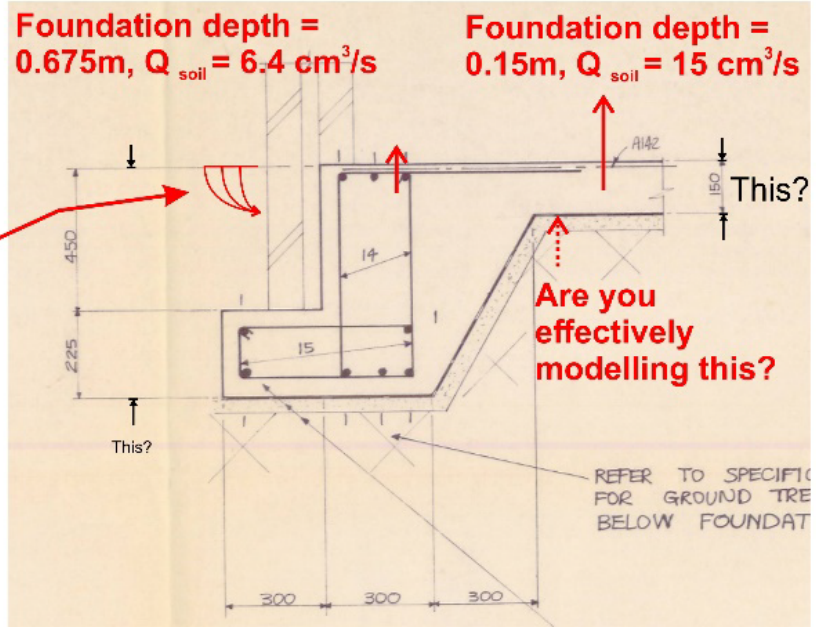
Depth of screed only?



If you use slab thickness as depth of foundation in CLEA this is what you are modelling on this site (assuming you use depth of block only as slab thickness)

Complete nonsense!

Application to an actual floor slab/foundation design - raft



If you use slab thickness as depth of foundation in CLEA this is what you are modelling on this site

Complete nonsense!

L_{crack} or crack depth in floor slab

Depth of main slab ?

Depth of edge beam ?

C4SL for residential without plant uptake - Benzene

- Vapour pathway is 99% of contribution
- The report recognises that site specific assessment will be required because of deficiencies in model – can be extended to include the effect of membrane

over-estimation can be up to several orders of magnitude.

Estimation of indoor air concentrations using Johnson and Ettinger model for UK building stock. The CLEA model uses the J&E model which is likely to over-estimate the indoor air concentration of benzene in a large proportion of UK building stock. The extent of over-estimation is anticipated to be up to several orders of magnitude.	● / +++

- But is it far too over conservative for screening and should we really be using a model where the CSM is wrong – even for screening?

Final thoughts

- RB17 is a robust and quick method of defining gas risk on sites with low to moderate gas potential
- It is included in the updated BS8485: 2015
- Lessons learnt about gas monitoring to provide more realistic assessment of gas in surrounding ground
- Guidance on VOC migration through membranes is now available from CIRIA

Thank You

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