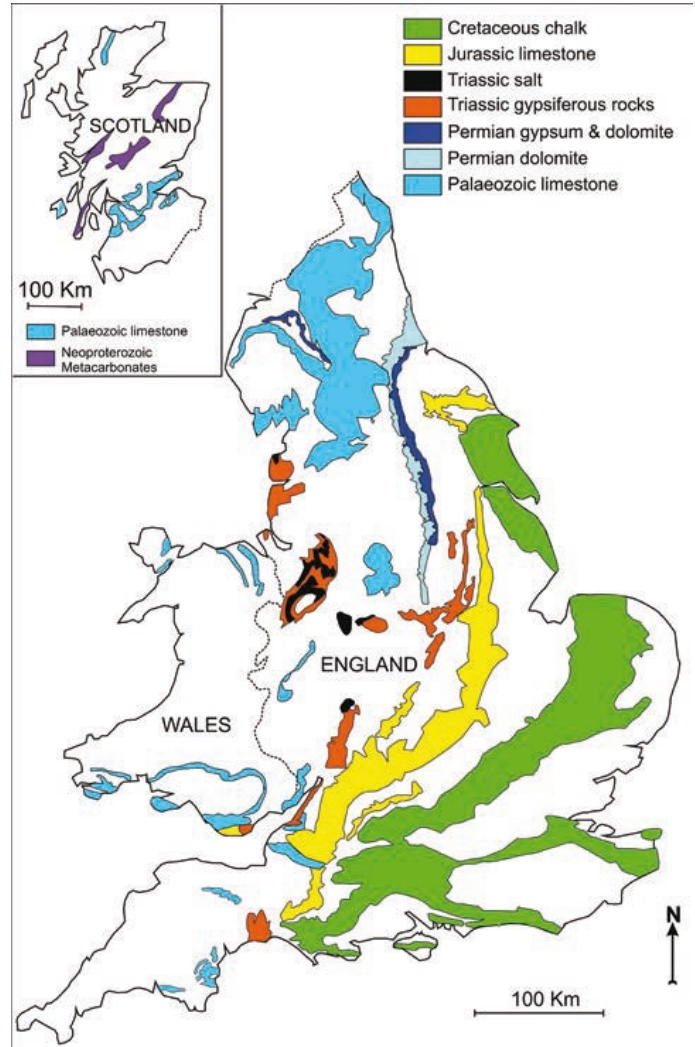


SOLUTION FEATURES IN SOLUBLE ROCKS

LABC Warranty's Surveyors and Engineers are required to assess the structural design and installation of foundations in soluble rocks as part of the audit process on behalf of the Underwriter. The following guidance outlines recognised good practice with regards to the design of foundations in soluble rocks that is acceptable to LABC Warranty. Foundation design and installation should be in accordance with the LABC Warranty Technical Manual and recognised publications from British Standards, Eurocodes, CIRIA, BRE, ICE, FPS and LDSA.

Solution features (such as pipes, swallow holes and solution cavities, sometimes loosely infilled with drift deposits) are commonly found in chalk although they can be found in limestone and other soluble rocks. The British Geological Survey categorises the five main soluble rocks found in the UK as Chalk, Limestone, Gypsum, Dolomite, and Salt. The occurrence of these deposits is shown on the map below from the British Geological Survey 'UK Geohazard Note' from March 2014 on 'Soluble rocks'.

Although there are serious risks to foundations from Gypsum, which are extremely problematic especially in areas around Ripon in North Yorkshire, as can be seen from the map these areas are relatively small. The major area of concern are the much larger areas of Chalk, which is generally found to be a much softer rock than Limestone.



SOLUTION FEATURES IN SOLUBLE ROCKS



KEY REQUIREMENTS

The foundation scheme shall be designed to clearly demonstrate that the foundations are capable of supporting and transferring the design loads safely to known soil strata that can be demonstrated from the appropriate project site investigation report to be capable of carrying the load, using the appropriate soil properties obtained from geotechnical testing. Where there is a moderate to high risk of voids being present, the foundations shall be designed in the first instance to span across a void of at least 5 metres without settlement greater than 25 mm (10mm for piles) or differential settlement tilt greater than 1:500 for low rise buildings unless more stringent criteria are required by the Project Structural Engineer. For buildings greater than 3 storeys please contact LABC Warranty.

TECHNICAL DOCUMENTATION REQUIRED

The following documentation shall be submitted to LABC Warranty for assessment. In the absence of approval, works are proceeding at the Developer's own risk.

1. A detailed Site Investigation Report is required. The risk of solution features should be addressed in the Report (commonly from an Envirocheck or GroundSure report on geological hazards, both on-site and locally). Where the risk is moderate or high, the spacing of boreholes should be significantly reduced. Where a void or dissolution feature is suspected, further boreholes should be undertaken to establish its size and depth, and whether there are other voids in the area (dissolution features are commonly found grouped together) The Site Investigation Report should also include an assessment of the level of the water table, which should be based on readings over an appropriate interval of time (months rather than weeks)
2. Geotechnical Specialist's conclusions concerning the presence of solution features following Site Investigation Report and probing, with recommendations for foundation solution, in line with this guidance
3. Calculations and drawings for the preferred foundation solution including the design of the foundations to bridge across any dissolution feature, equivalent to a void at least 5 metres in diameter, which might develop anywhere underneath the foundations

4. Where the foundations are not able to be designed to bridge a 5 metre void, then calculations and drawings for a piled foundation solution may be considered. Piles should be designed in accordance with CIRIA PR86 and CIRIA 574. Where possible, piles should be extended below the water table to transfer the vertical working load into chalk below the level of any dissolution features. A CPT (Cone Penetration Test) should be undertaken at each pile location prior to pile installation
5. The volume of concrete in each pile should be carefully monitored, and any over-supply (in excess of 10%) should be considered a potential dissolution feature and appropriate precautions taken (i.e. amended pile design and/or additional site investigation)
6. Soakaway drainage should be avoided if at all possible but, if unavoidable, should be sited at least 20m away from any foundations. The preferred solution is to avoid soakaway drainage

If there are queries with regard to anything not covered within this document and or it is intended to deviate from the above guidance, then please contact LABC Warranty for agreement prior to commencement. Following acceptance of the proposals, please contact us if anything is subsequently discovered on site, which affects the design and / or construction.

REFERENCE DOCUMENTS:

Building Regulations – Part A
 BS EN 1990 to BS EN 1997 including all parts and National Annexes.
 CIRIA PR86 – Shaft Friction of CFA Piles in Chalk.
 CIRIA 574 – Engineering in Chalk, 2002.

SOLUTION FEATURES IN SOLUBLE ROCKS

SITE INVESTIGATION

The risk of solution features should be addressed in the Site Investigation Report (commonly from an Envirocheck or GroundSure report on geological hazards, both on-site and locally). Hazard maps are available with different coloured areas representing different levels of risk. Where the risk is moderate or high, special precautions should be taken, as outlined below, and the spacing of boreholes should be significantly reduced. Where a void or dissolution feature is suspected, further boreholes should be undertaken to establish its size and depth, and whether there are other voids in the area (dissolution features are commonly found grouped together). The Site Investigation Report should also include an assessment of the level of the water table, which should be based on readings over an appropriate interval of time (months rather than weeks).

SPECIAL PRECAUTIONS TO BE USED WHEN THE RISK OF DISSOLUTION FEATURES IS MODERATE TO HIGH

Treatment of Dissolution Features in Foundation Design CIRIA C574: Engineering in Chalk, 2002 gives recommendations for how dissolution features should be treated in foundation design. Although dissolution features can be treated either by mass excavation and replacement (with compacted stone or mass concrete), or by grouting, there can be problems with these approaches. They tend to be expensive, and grouting can lead to destabilising “dissolution features by disturbance arising from vibration, displacement and erosion by both the flushwater and the grout. This could be 10 metres or so distant from the area undergoing treatment as a result of interconnection through horizontal discontinuities.”

BRIDGING OF DISSOLUTION FEATURES (5 METRE VOID)

The preferred solution is to design the foundations to bridge across any dissolution feature, and the recommendation in CIRIA C574: Engineering in Chalk, 2002 is that “the structure and floor slabs should be capable of bridging over any void 5 metres in diameter, which might develop anywhere underneath it. This is commonly achieved by forming the footings as a series of orthogonal grillages or raft”. The construction of the foundations should be accompanied by careful inspection of the excavation by a qualified Geotechnical specialist, and probing at 1 metre centres using a Mackintosh or Perth Probe, or other equivalent probing tool to a depth of at least 3 metres, to investigate all soils within influencing depth of the foundations.

On sites previously classified as low risk, should a potential dissolution feature be encountered during excavation/ inspection/construction of the foundations, the foundation design should be amended accordingly to ensure that the soils within the feature are not required to provide long term support to the foundations. This will likely involve, as considered appropriate, those steps undertaken on sites with a moderate and high risk of the presence of dissolution features.

PILED FOUNDATIONS

Piling is not preferred as a foundation solution as there are problems presented by “metastable materials and cavities. These can be temporarily destabilised by disturbance during pile installation arising from both vibration and the use of flushwater. In addition, for grouted mini-piles, the head of grout can destabilise areas 10 metres or so distant as a result of interconnection through horizontal discontinuities”.

Where it can be clearly demonstrated that the foundations are not able to be designed to bridge a 5 metre void, then piled foundations may be considered. To effectively manage the risks where piled foundations are used, good practice is to follow the recommendations below:

- CIRIA PR 86 ‘Shaft Friction of CFA piles in Chalk’ recommends “that a CPT (Cone Penetration Test) is undertaken at each pile location at sites identified during desk studies to be prone to dissolution”
- CIRIA C574: Engineering in Chalk, 2002 recommends that the piles should transfer their load to beneath the base of any dissolution feature. Where possible, piles should be extended below the water table to transfer the vertical working load into chalk below the level of any dissolution features. A permanent casing should be installed below the base of any dissolution feature to ensure the integrity of the pile where voids or loose material may be encountered, and the pile length should be increased to obtain the sufficient penetration below this level to carry the required loads

Piles should be designed in accordance with the recommendations of the Piling Good Practice Guide. To counteract any unknown conditions and make allowance for the presence of voids, redundancy should be applied (commonly an additional 50% to allow for the loads on a failed pile being carried by the two nearest adjacent piles).

SOLUTION FEATURES IN SOLUBLE ROCKS

DRAINAGE

The potential effects of soakaways, leaking drains, run off, etc. on the chalk will need to be considered and addressed in the design. CIRIA C574: Engineering in Chalk, 2002 gives the following recommendations:

Concentrated ingress of water into the chalk can initiate new dissolution features, particularly in low density chalk, and destabilise the loose backfill of existing ones. For this reason, any soakaways should be sited well away from foundations for structures or roads, as indicated below:

- In areas where dissolution features are known to be prevalent (moderate and high risk sites), soakaways should be avoided if at all possible but, if unavoidable, should be sited at least 20m away from any foundations. The drainage system and soakaways should be designed and validated by an appropriately qualified expert
- For drainage systems, flexible jointed pipes should be used wherever possible; particular care should be taken for the avoidance of leaks in both water supply and drainage pipe work
- As the chalk is a vitally important aquifer, the Environment Agency and Local Authority must be consulted when planning soakaway installations where chalk lies below the site, even where it is mantled with superficial deposits

If there are queries with regard to anything not covered within this document and / or it is intended to deviate from the above guidance, then please contact LABC Warranty for agreement prior to commencement.