South Australian
Department of
Mines and Energy

Information
Sheet
16

SOIL TESTS and HOUSE FOUNDATIONS in ADELAIDE

INTRODUCTION

Adelaide's unusual soils have caused problems for home builders since the early days of settlement. Cracked walls, particularly in older homes, are common, and in some extreme cases, houses have had to be demolished because of them.

However, it is possible to minimise the effects of Adelaide's problem soils by careful design and maintenance of buildings and of the land on which they stand. The Department receives many enquiries about soil testing and the nature of problem soils. This information sheet is designed to answer many of these and to tell you where to get more detailed advice.

GEOLOGICAL BACKGROUND

The soils of the Adelaide area have been formed by geological processes which have taken place over the last one and a half million years. During this period, several Ice Ages have occurred when sea level fell as water became locked up in the polar ice caps. The climate was cold and dry and lime-rich dust, derived from shell banks exposed on the continental shelf, was blown over the landscape by strong winds. Warmer and wetter periods occurred between the cold spells when layers of silt and clay were deposited on swampy river floodplains.

These changing geological conditions have given rise to the great variety of soil types found in the Adelaide region. When combined with present day climatic extremes, many of these soils require the careful attention of the homebuilder.

WHAT ARE PROBLEM SOILS?

In the Adelaide region, three main types of problem soil have been identified.

Expansive Soils

These are clay soils which show changes in volume with changes in moisture content: they swell when wet and shrink when dry. It is this change in volume that has caused much of the wall cracking so common in Adelaide's suburbs.

The volume changes may be due to seasonal climatic changes or to alteration of the natural environment by the building and its services, or by garden development.

The terms 'Bay of Biscay Soils' and 'Black Earths' have been used to describe the more strongly expansive soils.

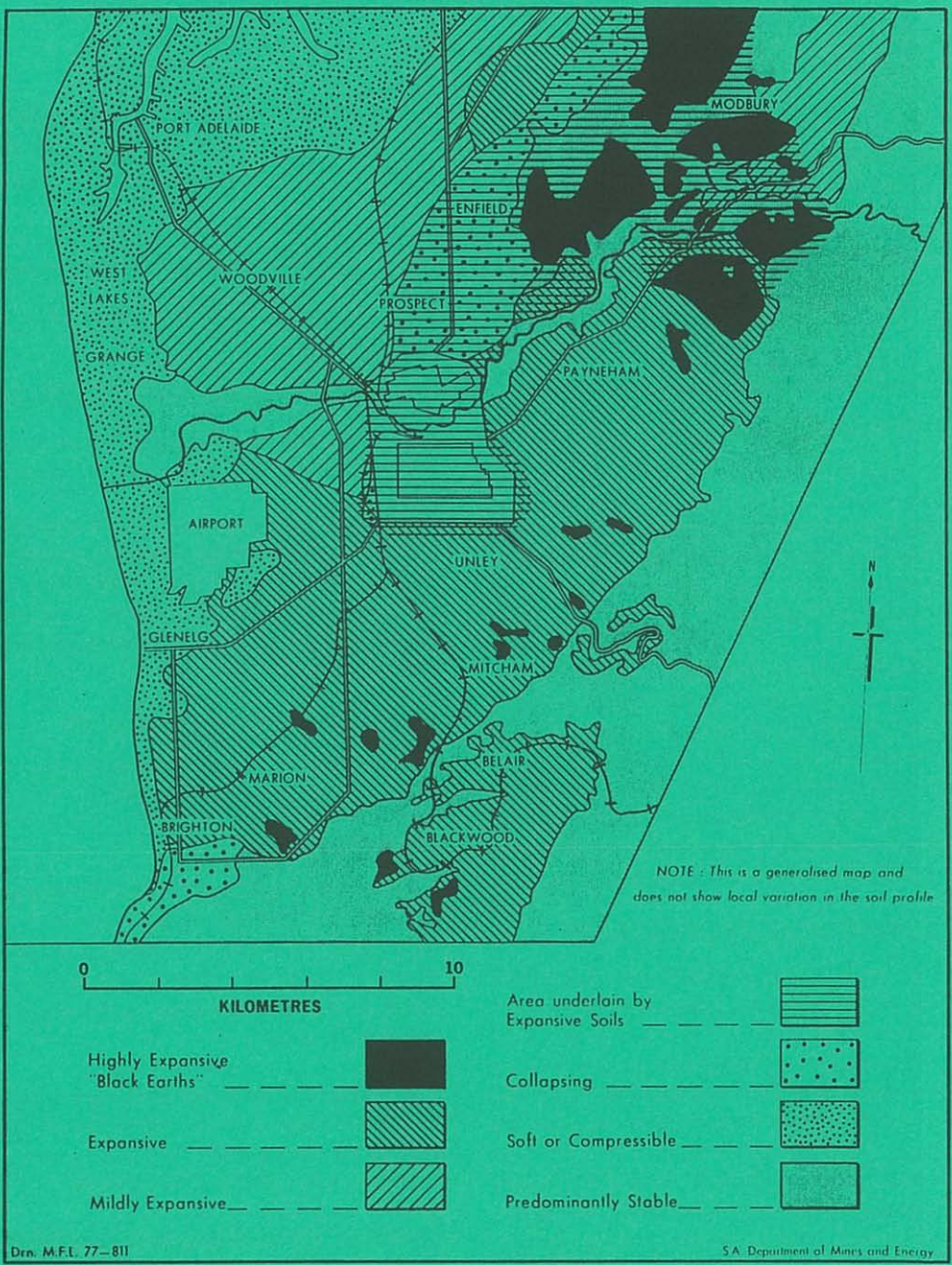

Figure 1. Soils of the Adelaide region.

Collapsing Soils

When wetted beyond a certain limit, collapsing soils lose strength and are liable to settle suddenly even under their own weight. They are usually fine, limy silts or loose sand of windblown origin. In the Adelaide area, they occur on the seaward side of hills and fault scarps, reflecting the direction of onshore prevailing winds. Collapsing soils can also occur within other soil types where they have been modified by the activity of worms and other burrowers.

Soft or Compressible Soils

Consisting of silt, fine sand and mud, these are unable to carry building loads without long term settlement. They occur chiefly on the coastal river estuaries where they are associated with high water tables and restricted surface drainage. In the metropolitan area, large tracts of this land have been successfully reclaimed for housing development, as at West Lakes and North Haven.

Some soils in the Adelaide area are *stable*; these include alluvial sand and gravel, and most weathered rocks.

Figure 1 shows the general distribution of the above soils in the Adelaide region. A coloured version of this figure, and more detailed maps are available from the Department. When using these maps, remember that soils generally occur in layers forming a soil profile. It is possible for combinations of soil types to occur together in this profile on a particular site. Soil maps are therefore approximations and should not be used as a substitute for a soil investigation.

Problem soils occur in other parts of metropolitan Adelaide and elsewhere in the State. These areas have not yet been mapped in detail.

THE SOIL INVESTIGATION

As a result of these problem soils, most councils and all lending authorities require a soil investigation before granting building approval. Soil samples are taken from test pits or drillholes to determine the engineering properties of soil layers that make up the foundation for the proposed building.

Results of the soil investigation are used to design suitable footings for the proposed building.

The Institution of Engineers Australia has published guidelines on the design of residential footings for South Australian conditions. It is recommended that a qualified Consulting Engineer be engaged to prepare a soil investigation and footing report for your building. These are listed in the Telecom Yellow Pages under 'Soil Investigation and/or Stabilisation.'

There are two types of soil investigation report.

Preliminary Report

Designed to give general advice on a site before purchase or for estimating costs, it should identify any major problems on the block and describe the main properties of the soil profile. It should also give general advice on site preparation, possible footing types, drainage and paving. Preliminary reports should never be used for construction purposes.

FOOTINGS AND FOUNDATIONS

The term *footing* refers to that part of the building in direct contact with the ground. The *foundation* is the soil or rock on which the footing rests. Footings are sometimes incorrectly referred to as 'foundations'.

Construction Report

This gives sufficient information for the builder to construct a house that, if properly maintained, is unlikely to be affected seriously by problem soils. It should include a plan of the footing prepared specifically for the proposed building and the site, and a specification for the contractor to follow. If alternative designs are presented, you should ensure that one of these has been given preference for your site. The report should also contain detailed advice on any other problems that may arise from the site or soil profile, such as drainage, stability of cut and fill, need for retaining walls and pavements, etc. A soil salinity test is also recommended to assess possible problems with salt damp. The floor plan and type of construction of a house must be finalised before a construction report can be prepared.

It is important that you specify exactly which type of soil report you require, especially when obtaining quotes. Make sure that the report is signed by the engineer in charge of the work. The engineer is legally responsible for the design of all structures based on his report, but remember that it is rarely possible to design a footing to give negligible damage. Most engineers design for slight damage where the crack width in walls is less than 0.5 mm.

To ensure that the house is built according to the design, you should specify whether you require site inspections by the engineer, and whether you want him to supply a certificate covering the footing construction.

Recommendations regarding drainage, landscaping, and maintenance, included in the soil report, should also be carried out promptly.

DESIGN OF FOOTINGS

Various types of footing have been designed to cope with Adelaide's problem soils. These are in use in other parts of the world where similar problems occur, but have been adapted in many cases to suit local conditions.

The footing type required for a house will depend on the type of construction, floor system, drainage, and distribution of soil and rock on the allotment. The Engineer is the person who is technically competent to select the correct type of footing to be used in each particular set of building and soil conditions.

Correct design and installation of damp proofing is essential in the construction of all types of footing.

HOUSE CONSTRUCTION

The type of wall construction and interior finish can be important in masking visual evidence of cracking caused by foundation movement in problem soils. Houses can be divided generally into four main classes, although often a house may be a combination of these.

Solid Brick or Cavity Wall

This has been the traditional form of home construction in South Australia for many years. Buildings of this type can be brittle and the continuous brickwork over doorways, windows, and arches may crack under the influence of only small foundation movements.

Articulated Brick

Here the walls are broken into separate sections, which are free to move relative to one another. This can be achieved by use of full height door and window frames, and inclusion of panels where openings are

not required. Alternatively a vertical control joint may be formed in the brickwork on both inner and outer walls which may be visible. Use of articulation can allow a more economical footing to be designed.

Brick Veneer

This type of construction, with its internal timber or steel framing and plasterboard skin, is flexible and more capable of absorbing foundation movements. Cracking of the external brickwork can be minimised by the use of concealed vertical joints. Brick veneer houses can be articulated by use of timber beams over windows and doors, which extend up to the eaves line.

Timber or Prefabricated

These structures are the most flexible and can accommodate large foundation movements; the footings often consist only of pads or supports to keep the structure off the ground. They have much to recommend them in problem soil areas, and in areas subject to earthquakes.

SITE WORK

Before constructing footings, it is important that clearing and removal of all ground vegetation and roots is carried out to at least a metre beyond the building area; the soil removed in this way can be stockpiled for later garden use. Trees should be removed a considerable time before construction commences as they can have a major influence on the behaviour of problem soils.

Artificial Fill

The use of filling on home sites is common, and quality and standard of compaction can be such that the filled area is denser and more stable than the natural soil. However, fill placed without proper compaction control, or placed previously and with unknown history, can cause building damage through settlement. Existing areas of fill, such as gullies, old cellars, quarries and rubbish dumps, should be identified in the soil investigation. However, with a limited number of boreholes it may be difficult to locate small filled areas in a building site and this should be allowed for during footing construction. On all sites where fill exists or is to be used the recommendation of the Engineer should be followed.

Sloping Sites

The most common method of dealing with a sloping site is by excavation of a bench (Fig. 2). The excavated slope (or batter) must be flat enough to prevent sliding of soil or rock, and this should be specified in the soil report. Protection against erosion by runoff or seepage must be achieved, and

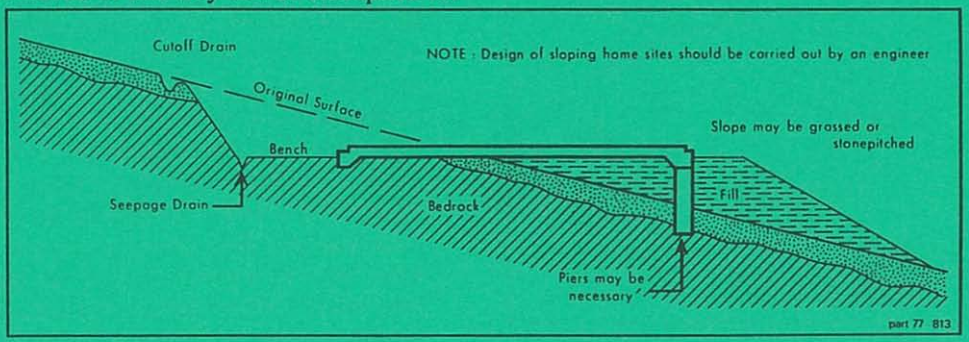

Figure 2. Typical cut and fill.

adequate clearance left between the bottom of the slope and the walls of a house. Fill obtained from excavation of the bench is usually placed downslope to form a level building and lawn area. If the house is to be built partly on the filled area, engineering control during placement is essential. Uncontrolled filling is regarded by engineers as suspect, and pier and beam footings may have to be used to carry the building load onto the original soil or rock.

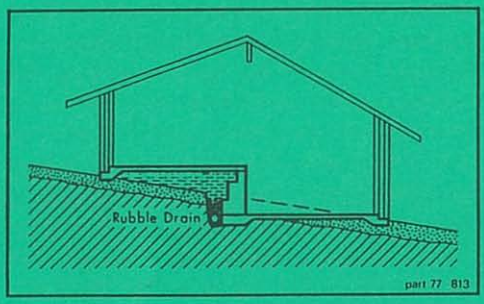

Figure 3. Typical split level arrangement.

Split level houses are often used on sloping sites as they involve minimal disturbance to stability of the natural slope, reduce environmental impact, and make final landscaping and drainage easier. Where part of the house occupies an excavated area below original ground level, construction of a drain below floor level will prevent problems associated with seepage of groundwater after heavy rains (Fig. 3).

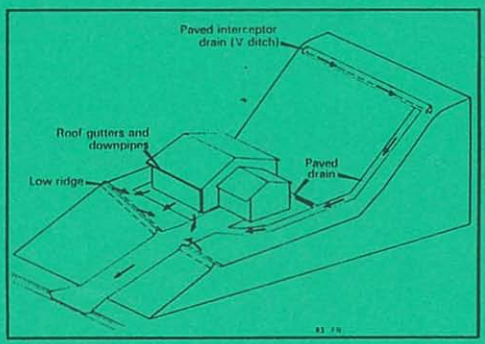

Figure 4. Drainage on a sloping home site.

Correct drainage is critical on sloping sites particularly where fill has been placed (Fig. 4).

Site Maintenance

This is most important in problem soil areas. It is essential that recommendations made by the engineer, as part of the soil test, are followed up promptly during and after construction.

Some points to remember:

- Plan garden beds and lawns so that they are kept away from house walls and ensure that all drainage from watering is away from the house. When watering gardens and lawns avoid wetting the walls.
- Always remove any rubbish that is accumulating near walls. Check your garden taps and pipes and fix any leaks immediately.
- Check gutters regularly and clean out blockages. Every winter check that stormwater is draining freely away from the house and that no pools of water are forming near your walls.
- When laying protective paving around the house ensure that it is at least a metre wide, reinforced to minimise cracking, and sealed to the outer wall with a mastic compound. The paving should have a fall away from the house walls and a gutter drain is recommended at the outer edge. Ensure that it does not bridge the wall damp proofing. Use of a compacted sand layer to provide a base for the concrete is not recommended as this can provide a leakage path to the footing.

Tree Roots

Trees placed close to buildings can be a major cause of cracking. This can be even more pronounced during drought periods when a tree will activate its root system to obtain additional moisture from the soil. This removal of soil moisture causes shrinkage of expansive soils which can lead to cracking of walls and footings. For this reason, trees, particularly some native varieties, should not be planted close to buildings in areas of expansive soil.

Removal of large trees may create the opposite problem: as natural soil moisture is gradually restored expansive soils can swell and cause movement and cracking.

CRACKS IN EXISTING HOUSES

This is a major problem in Adelaide, particularly in older houses constructed before the mechanism of problem soils was fully understood. Cracking may be caused by defects in the design or materials, or by techniques used in construction. However, cracking as a result of soil movement is most common. It may be due to one single isolated cause, such as incorrect disposal of roof runoff or a leaking sewer pipe, and in these cases can be localised. Widespread cracking throughout the building generally implies an inadequate footing design, which has become overstressed. Most foundation movement in older houses is a result of a long term change in the soil moisture, which can be caused by the following (Fig. 5).

Shrinkage

Changes to the soil environment caused by a house with timber floors can lead to drying out of foundation soils. At the same time, long term effects of garden watering or inadequate disposal of storm water can lead to expansion of soils beneath the walls.

This shows as an apparent settlement of interior walls, and is a type of cracking common in older houses on expansive soils.

Heave

Occurs beneath concrete rafts due to a long term rise in the general moisture content of the foundation. This can occur particularly if the soils were dry at the time of construction. Movement of this type causes cracking over doorways, particularly in internal cross-walls.

Localised Settlement

If a reasonably stable moisture content is not maintained all around the house, cracking due to localised movement can occur. This can happen on cut and fill home sites where the footings may rest partly on rock, natural

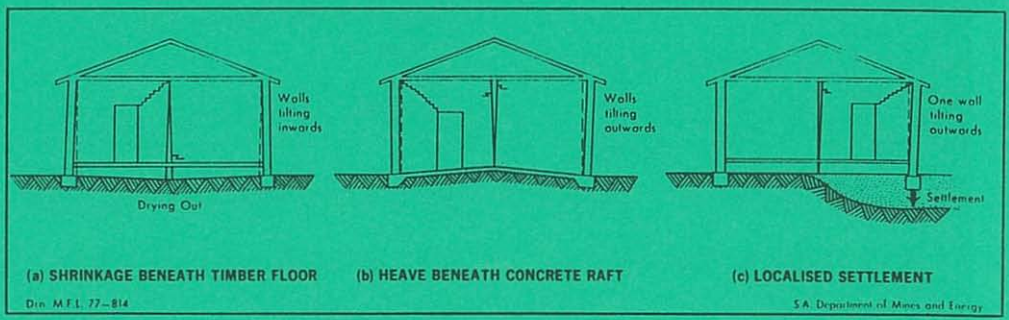

Figure 5. Common types of foundation movement.

soil, and fill. In problem soil areas, check for possible causes of localised cracking such as faulty storm drains, over-watering, leaking pipes or swimming pool. Removal of well established trees close to the house, especially natives and poplars, can cause upward movement in expansive soils. Installation of a large modern heating unit in an older home can cause settlement of interior walls in its vicinity.

A new owner may make changes which will destroy an equilibrium established over many years, and cause foundation movement to occur.

When purchasing an existing house where cracking is known or suspected, it is recommended that you arrange an inspection by an Engineer.

SALT DAMP

This is a major problem with many of South Australia's older houses. It is caused by a combination of extreme climatic conditions and the high salt content of many foundation soils. Rising damp causes the formation of salt crystals which cause mortar, brick and stonework to crumble and flake.

It has been estimated that nearly a quarter of a million houses are affected within metropolitan Adelaide, many of them of recent construction.

Some causes of the problem have been identified as:

- Ineffective damp-proof course, which may be totally lacking in older buildings.
- Inadequate ventilation under suspended timber floors caused by blocking of wall ventilators.
- Poor building practice, particularly bridging of cavity walls with waste mortar, use of sub-standard bricks, faulty installation of damp course or the moisture barrier on raft footings, and bridging of the existing damp course by extension of rendering or paving.

Companies offering treatment for salt damp are listed in the Telecom Yellow Pages under 'Salt Damp Curers'. The most reliable method is to replace the affected material and install a damp proof course.

FURTHER INFORMATION

Residential Slabs and Footings. Australian Standard AS 2870.1 (1988) and AS 2870.2 1990.
Standards Association of Australia,
853 Port Road,
Woodville,
SA 5011.

Guide to Home Owners on Foundation Maintenance and Footing Performance.
CSIRO, Division of Building,
Construction and Engineering,
PO Box 56,
Highett,
Vic. 3190.

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