Foundation Course

Whatever type of home you decide to build it will be built on top of concrete but the kind of foundations you need and how much they cost will depend largely on ground conditions explains Mark Brinkley.

Concrete has been the material of choice for foundations for most of the last century. Before it became widely available in the 1920s foundations were a hit and miss affair, often amounting to nothing more than a couple of extra wide courses of brickwork below ground level. And whilst millions of British homes survive to this day on the flimsiest of foundations, the ability to build off a rock-like surface is so highly valued that it is now virtually unheard of to attempt anything else.

Whatever style of house you choose to build, it will be built on top of concrete. Provided ground conditions are good, foundations for houses are usually strips of concrete poured into straight sided trenches. These trenches can be dug by hand but where access is no problem, it is now usual to have them excavated by a machine such as a JCB or tracked digger which does the job quickly and accurately. It is conventional to dig down around one metre below ground level. The building inspector needs to be called in to inspect the open trench to check if the ground at the bottom of the trench is firm and sound. If it passes muster, the readymix is usually poured right away.

Strip Footings v Trenchfill: There are two competing techniques for laying house foundations on problem-free sites. One is to pour the minimum amount of concrete possible into the foundation trenches and then build upwards in brick or blockwork; this is known as strip footings. The other system reverses this logic and pours as much concrete as possible into the trench before starting on the bricklaying; this method is usually referred to as trenchfill, for obvious reasons.

Both methods have pros and cons. The traditional method, laying footings below ground level, uses less concrete but takes longer and is more costly on labour. The increased speed of using trenchfill means that it's now the method preferred by most professional builders.

What really tends to swing it for the trenchfillers is that a high proportion of the labour element goes into setting levels for the concrete to be poured to and that this work is the same whatever the concrete level. Add to this the fact that much of the graft of foundation pouring has been taken away by the increasing use of concrete pumps which do away with the need for barrowing, and you can see why trenchfill is tending to win out.

Whichever method you choose, you need to ensure that the concrete is poured to a preset level and that it is tamped down before it starts to harden. The depth of the trench is not in your control, but the trench width is largely down to which bucket is used (the general choices being 450mm and 600mm wide). Using a 450mm wide bucket is going to reduce the amount of readymix used by a quarter (as well as reducing excavation costs) but it is not to be recommended to inexperienced builders. Cavity walls – generally now 300mm wide – sit uncomfortably on such a narrow trench; single skin brick masonry (as used in the garage) is obviously less of a problem but the key factor in all this is accurate setting out of trenches.

Unless you are an experienced surveyor, you really want to play safe and set trenches at 600mm wide, because not to do so is to risk not having square footings. This will end up costing you far more money than you may save through having narrow trenches.

▲ **Most new homes have a poured oversite slab, comprising of compressed hardcore, a dpm layer, insulation and 100mm of readymix, tamped down to remove air and leave a smooth, level surface.**

Problem foundations: Not all foundation work is as simple as that described earlier. Many self-builders get caught out by 'unexpected' increases in the cost of foundations as they meet ground conditions which normal foundations can't cope with. The list of possible problems is worryingly long; some of the more common ones include clay soils, the presence of tree roots, bog conditions, mining subsidence, wells, water courses, old factory workings and aggressive acid soils which can attack the concrete. It's worth carrying out any amount of detective work to ascertain exactly what has happened on your site because the ramifications can be expensive.

One very fundamental problem is caused by having soft or variable ground. This will ▶

Case Study One: Raft Foundations

Mary Banham's spectacular home is built on a concrete raft. It occupies a peaty site in the Fenland village of Prickwillow in Cambridgeshire where the land is said to be "reclaimed from the sea", despite the current shoreline being over 30 miles away.

Traditional foundations are inadequate in this area because the subsoil is unstable – it keeps sinking. The house was designed and construction overseen by Mary's neighbour, architect Jonathan Ellis-Miller who is a confirmed raft man. "Actually, we use both rafts and piles," said Jonathan. "But I am always a bit cautious about piling because it's much more technical and has to be carried out by specialists. Often they can only give rough estimates of how much the work will be before they start because they don't know exactly what they are going to find when they start drilling. The beauty of rafts is you know where you are before you start. Not only can you predict the costs pretty accurately but rafts are low-tech in comparison with piling and laying concrete rafts are well within the scope of a good local groundwork contractor. This makes it more amenable to self-builders."

However, engineers who design rafts are careful to add a note of caution. "I wouldn't recommend a raft to a self-builder, certainly not without having the whole thing supervised by a suitably qualified engineer," says NHBC's Mike Atkinson, author of the Structural Foundations Manual. "The trouble with rafts is that whilst they are fine in some situations, there are places where they shouldn't be used. The ground needs to be good bearing ground otherwise there is a risk that the whole raft will tilt. You can't really design a raft without having a close look at the ground underneath – good engineering judgement is essential if the raft is to be problem free."

tend to cause subsidence in the walls above, as the building absorbs the movements going on underground. The remedy is to design foundations to cope with these conditions.

Tree roots are another problem; in dry weather they will extract more groundwater than can be replaced by rainfall. This causes some soils, notably clays, to shrink, only to expand again when wet weather returns in autumn. Cutting down the trees makes little difference in the short term – the roots continue to be active for up to ten years after the tree is felled.

With soft ground conditions and/or large trees nearby, the solution is usually to get the foundations down to the right depth and onto solid ground. Both the NHBC and Zurich – the organisations that issue most structural defects insurance policies – provide guidance on the depth of foundations needed with different tree species at various distances.

With some clays it is also necessary to isolate the concrete foundations from the seasonal movements of the ground caused by tree roots. This is done with clay boards which line the trench before concrete is poured.

Another consideration is the aggressiveness of the ground and the groundwater. Soil types range from those that have no effect at all on concrete to those which react with concrete; these are said to be "aggressive." The usual culprits are sulphates and acids. Many clays contain sulphates and they are often found in ground water in coal mining areas.

Brownfield sites, especially industrial ones, can present a cocktail of nasty chemicals which can rot concrete. Fortunately, these problems can usually be countered by using sulphate-resistant concrete, usually one of the designated concretes FND2, FND3, FND4 or FND4M.

There are solutions to all of these difficult ground conditions but they naturally involve extra cost. The key to managing the problem is to get good advice early on in the building process, ideally before you have even purchased the plot. A site appraisal is likely (but not definitely) going to uncover the problems you will meet below ground and your foundation design is almost definitely going to be in the hands of an engineer.

Besides altering the concrete mix, there are other options which an engineer is likely to suggest:

- Deeper foundations (sometimes reinforced with steel)
- Raft foundations
- Piling.

In extreme ground conditions, the engineer may even specify designed drainage to remove aggressive ground waters and/or protective coatings away from the concrete.

Deeper Foundations: As discussed already, you will have to excavate to good bearing ground (if it's there). If it's just a question of going down to two metres below ground, you may be able to use a standard trenchfill foundation. But this will be expensive; on a four-bedroom house it will add around £300 for every extra 100mm depth you have to dig down. At this depth you may do well to consider the possibilities of building a basement – though this is not something to be added as an afterthought, it needs both planning permission and careful planning beforehand. This will be discussed in Parts Three and Four of this series.

Whether you go for a basement or not, when foundations get much deeper than two metres below ground level, it usually becomes cheaper (and/or easier) to specify one of the alternative foundation systems of which the most common are concrete rafts and piling.

"Many self-builders are now having ground investigations undertaken as part of pre-sale enquiries."

Rafts: On a problem-free site, the floor slab is conventionally laid a couple of stages further on than the foundations. However, with a raft you pour the foundation concrete and the floor slab concrete in one operation and then build the superstructure of the house on top of this concrete raft. With various cambered design profiles and a whole mass of steel reinforcement, you create a platform which will move as one. If subsidence occurs, the raft will absorb the changes without imposing extra strains on the house above.

Rafts are relatively easy to build but they can't be used in all ground conditions. It is essential that the ground is examined by a qualified engineer to assess a raft's suitability.

Piling: Piling is usually reckoned to be the solution of last resort but it has become steadily cheaper over the years and many housebuilders are now calling in a specialist piling team the moment any non-standard conditions are discovered. Piling involves boring down until firm ground is reached and then placing concrete into the holes. The piles

are linked at the top with a structural ring beam, off which the house is then built. The number of piles and the depth of each pile can only be determined by a test bore, but a typical installation would place piles 2.5m apart under every load-bearing wall including such features as detached garages.

Reassurance: These non-standard foundations are expensive and surprisingly common. They will, typically, double or treble foundation costs which is enough to blow a hole in the budget of most self-builders.

The question is, are these costs predictable? Mostly they are. Problems caused by the proximity of tall trees are entirely predictable – you only have to visit the site once to see what trees are about. Adverse ground conditions are more difficult to assess but the careful self-builder will carry out some investigations before ever starting work. Indeed many self-builders are now having ground investigations undertaken as part of pre-sale enquiries.

You wouldn't buy a house without a survey and really the same principle applies to building plots. A typical survey consists of a JCB digging trial holes and having an experienced eye, preferably that of a qualified structural engineer, cast over the underlying conditions.

This is likely to cost a few hundred pounds but it should highlight any problems underfoot. However, it is not completely foolproof, as Clive Harris's tale (Case Study 2) illustrates. The trial holes may well miss something. All you can realistically hope to do is to minimise the risk of having to build with special foundations.

Case Study Two: Piled Foundations

Clive Harris has built a bungalow in Surrey and ran into unsuspected problems with his foundations. "Before we bought the land I had a soil survey carried out by a supposedly reputable engineer. Apparently he dug down a few feet, found sandstone, and pronounced the soil suitable for standard foundations. Had he known the local geology or dug a bit further (as I found out later), he would have discovered the sandstone was only a few inches thick with blue clay underneath, compounded by numerous nearby broadleaf trees. Needless to say, exclusion clauses in his contract covered him for his omission.

"The Zurich Custom Build inspector and the man from Building Control got together on the site and, after roaring with laughter at the engineer's report, decided that they would require either piles or deep trench foundations. A neighbouring site had recently had terrible trouble with collapsing trenches so we decided on piles as the best solution.

Unfortunately, the unusual shape of the property made the foundation design more expensive then normal. Various planning restrictions forced us to build an 'L' shaped bungalow although we would have preferred a traditional rectangular house. The resulting piling design required twenty three 6mx300mm piles connected by a complex arrangement of reinforced concrete ring beams, all encased in special expanded polystyrene material known as 'clay board' to cushion the concrete against ground movement. The total cost of this arrangement came to around £13,000. (This was the middle of three quotes)."

Clive Harris's story shows that, even with preliminary investigations, you cannot be absolutely certain what you are going to find below ground. However, don't assume from this that it's not worth bothering to carry out a survey: ninety-nine times out of a hundred, a survey will turn up any problems before you start excavating.

Clive Harris' Piled Foundations Step-by-step

1) The mini auger drills out the ground for each pile, spaced 2.5m apart under all loan bearing walls. 2) The holes are lined and filled with reinforced readymix and the trenches dug. 3) The piles are linked with steel cages and the sides of the trench lined with compressible material to absorb ground movement. 4) Readymix is pumped into the trenches. 5) The concrete is tamped and levelled and the footings built up to dpc level. 6) The concrete floor beams are positioned. 7) Insulating concrete blocks are dropped into place. 8) The slab is levelled and completed using reinforced readymix screed.

Floors: Although there has been a significant growth in the number of suspended beam and block floors in housing, the solid slab floor remains most self-builders favoured method of providing a solid base. A solid ground floor usually consists of a concrete slab laid on top of hardcore (often called a sub-base). The topsoil is first removed and the hardcore then laid to consolidate the ground and level up the site. The rough surface of the hardcore is filled with a thin layer of sand (called a blinding coat) which is then rolled flat. On top of this it is now usual to lay a thick polythene sheet as a damp proof membrane (DPM): this stops any ground water from rising up into the floor. Many self-builders then choose to place a layer of insulation on top of this before pouring the 100mm thick concrete slab.

The slab itself is made from readymix concrete. The brick walls around the perimeter are built up just above the level of the top of the slab so that the readymix is contained and levels can be easily checked. Having been poured, the concrete is then tamped down (see picture on previous page) to remove the air and leave a smooth surface.

Concrete slabs are also used in garages and driveways. The mix tends to be rather stronger and sometimes steel reinforcement is called for as well but the basic principle of laying remains the same. You need to seek advice in this area. ■