CONCRETE BLOCKS AND MASS CONCRETE

Introduction

Many properties in the South West of England are constructed from concrete blocks laid onto mass concrete foundations. The main reasons for the use of concrete being: no suitable raw materials to make conventional red bricks, the ready availability of waste rock from mining operations and free supplies of beach gravel. The mine waste rock was commonly used as the coarse aggregate, together with a fine fraction (beach sand, china clay waste or mine processing reject) and cement to make a great variety of local types of concrete blocks. This took place from about 1900 until the widespread use of mass produced china clay waste or granite blocks and bulk ready mixed concrete in about 1950.

Problems

Several types of these local materials used as the aggregate in concrete can cause deterioration and mechanical weakening. The main problems are associated with:

1. Sulphide minerals, particularly pyrite, often found in mine waste and sometimes in quarried rock. These can oxidise under damp atmospheric conditions with the production of sulphuric acid. This attacks the cement, causing weakening and expansion. This is ‘Mundic Decay’.

2. Fine-grained sedimentary rocks, which are formed from sediments laid down in lakes, rivers or the ocean floor. These can often contain significant amounts of clay and subsequently can be quite soft. The presence of clay can also cause the rock to change volume and delaminate under cyclic moisture conditions, fracturing the cement of the concrete. The effect of ‘Killas’.

3. Furnace clinker, coking breeze and slag from metal smelters, gas works and laundries. These may contain unburnt coal which can expand when wet, cracking the cement, and often also contain sulphides.

4. Reactive forms of silica, such as flint and chert found in beach gravel, which can cause Alkali-Silica Reaction. This is not common in domestic concrete, but is sometimes found in high density mass concrete.

Other problems occur, particularly a lack of cement when the concrete is made from beach gravel. (Reducing the cement was the only effective cost cutting that could be made.)

Testing of Concrete

The recognition of structural defects in houses and the above causes has led to the need for a suitable testing method. Early tests relied on chemical analysis to detect the sulphide content of concrete. This method could not identify problems other than true mundic and results were confused by, for example, sulphur from flue gas in chimney blocks. Neither did this method actually identify the aggregate used. These tests were discounted in 1991.

The present Concrete Screening Test, published in the RICS Guidelines in 1994 and revised in 1997, with input from the Building Research Establishment and other experts, is designed to rapidly identify sound concrete that contains only suitable components, called Class A concrete. It will also identify major problems where the concrete is degraded or at extreme risk - Class C concrete. There is obviously sometimes a grey area between the two, for example where sulphides are present but at a relatively low content. These
materials require further testing work to resolve any doubts and to put the material into one of the other groups. The extra work is technical and expensive and is therefore only carried out when the Preliminary Screening Test cannot be conclusive.

**Preliminary Screening Test**

The Preliminary Screening Test involves the taking of a number of 50mm diameter drill cores from the external walls of the property, samples from the footings (usually 75mm diameter), where these are accessible, together with internal walls and chimneys. These samples are examined petrographically in the laboratory using a stereomicroscope. Petrography is the scientific description and classification of rocks. Identification of suitable rocks can usually be made easily at this stage and they are grouped into various categories, known as Type 1 Aggregates.

Examples of Type 1 Aggregates are:

Granite derived china clay waste (Type 1-1)
Crushed granite (Type 1-2)
Dolerite and gabbro from the Lizard peninsula (Type 1-3)
Furnace clinker with no excessive unburnt coal (Type 1-4)
Beach or river gravels (Type 1-5)
Granite mine waste with low sulphides, some altered sedimentary rocks (Type 1-6).

As well as identifying the Type 1 aggregates the Preliminary Screening Test will also report on the condition of the concrete. This includes the aggregate size range and grading, the type of sand used, the coating of the aggregate fragments by cement, the adhesion of cement to aggregates, the carbonation of the cement, any cracking of aggregates and cement, the size and connectivity of voids in the concrete and the presence of any secondary minerals in voids that could indicate reactions occurring in the concrete.

Providing these factors are satisfactory and the aggregate is Type 1, the concrete is Class A and the property can be passed. However, it should be realised that this does not constitute a guarantee. Other factors not connected with the aggregate, can cause deterioration of concrete and all concrete block properties need a reasonable degree of maintenance. That is why they are covered with a protective render.

For example, most cement in fairly porous domestic concrete will gradually carbonate. This is the reaction of atmospheric carbon dioxide converting the original cement minerals to calcium carbonate (calcite). This is not normally a problem, as the new mineral will also act as an adhesive. Sometimes though, the calcite becomes coarse and granular, in which case it can lose adhesion and can induce extra porosity in the concrete. Calcite is very slightly soluble and therefore excess moisture penetration will slowly leach out the cement and the concrete may become weak. Should the protective render coat become badly cracked, letting water in, then this process can lead to deterioration, despite the aggregate being safe.

In the event that the property cannot be passed as Class A or failed, in other words some element of doubt is present, then it is recommended that further work is carried out on the samples to resolve the position.
Stage 2 Examination

The examination is carried out on thin sections made from the original core samples taken from the property. These are made by taking slices of the core and then grinding the slices down until they are transparent (about 1/1000th inch or 0.03mm thick). They are examined by high power microscopy using various transmitted light techniques to identify the nature of the minerals present, any microscopic cracking, the nature of the cement minerals and the adhesion between the cement and the aggregate fragments. Usually, polished mounts are made at the same time. These are sections of the core, polished to give a mirror finish, and reflected light is used to identify sulphide minerals, their degree of oxidation and the effect on the cement. A significant amount of the cost of the Stage 2 work is in the preparation of these slides of concrete. Sometimes, chemical analysis is needed to quantify the amount of sulphides in the aggregate. Stage 2 work may require only density tests for footings mass concrete.

From these examinations it may be concluded that there is no serious damage to the concrete and that the potential for future deterioration is small, hence the concrete can be assigned to Class A. There is a further category of concrete, A/B, that is normally mortgageable, and this is a sound concrete that contains no more than 30% of deleterious materials; this category is also used for dense concrete. Sometimes, owing to the nature and proportion of potentially deleterious rock types found, the concrete has to be assigned to Class B, which is sound at present but carries a risk of deterioration.

Stage 3 Testing

In January 2002 a new procedure was introduced to further test concrete assigned to Class B. This involves additional sampling to obtain five 75mm cores which are then subjected to expansion testing at constant temperature and 100% humidity. Provided, after 250 days of testing, no core has expanded more than 0.04%, the concrete can be re-assigned to Class A/B.

Results

Over 15,000 properties have been examined by us, using the tests described above, covering most of Cornwall and parts of Devon. Some 80%, or four out of five, have been passed as Class A concrete at the Preliminary Screening stage. About 5% have gone straight to Class C. The remaining 15% have undergone Stage 2 Examinations and many of those have subsequently been re-graded as Class A or A/B and have passed.

Class C materials are usually recommended to be examined at the property by a Structural or Civil Engineer to assess the mechanical strength of the concrete and whether the property is at risk. Fortunately remedial work is often possible, either by replacement of the concrete by new materials, or by other strengthening techniques.