



Paring back new cob inserted as a repair at Bowhill, Exeter.

INTRODUCTION

The DHBT in its first leaflet on cob describes the history of the material and the way in which it was used in building. This second leaflet is intended to help those who have responsibility for cob buildings to maintain and repair them in the best way.

In contrast to modern buildings, traditional cob and thatch houses were constructed by local people from natural materials derived directly from the surrounding land and landscape. They are therefore in a very real sense 'organic' and like any organism they must, in order to remain healthy, be able to 'breathe' and to respond readily to variations in temperature and humidity. In seeking therefore to bring cob buildings up to modern standards by 'improvement' or alteration, the greatest care must be taken to avoid works which might upset this balance with the environment, as damage to the building may well be the consequence. Like all building methods cob has its own particular weak points, but the right approach towards these in its maintenance and repair should prevent any serious problems developing.

DAMPNESS IN COB WALLS

The principal cause of failure in cob walls is the presence of excess moisture. When too much water enters a cob wall the clay particles which bind it together are forced apart, and the cob is first reduced to a plastic then to a liquid state with consequent structural failure. The precise point at which this happens varies according to soil type and clay content but some cob walls made from very sandy soils deficient in clay and silt have been known to fail at quite low moisture levels.

While it is clear that excessive moisture can be very damaging to cob walls, the effects of excessive drying-out are more difficult to assess, although there is a common belief that this may lead to weakness in the cob. In fact there is no evidence to support this view. Cob walls will dry down to moisture levels as low as 1-3% by weight (drier than many masonry walls) with no obvious reduction in strength or flexibility.

RISING DAMP

Because cob walls are built off stone plinths, rising damp should not be a problem, as long as external land drainage is adequate. In particular a build-up of soil alongside or above the plinth may cause damp penetration; this should be able to be cured by a field drain as shown in Fig. 3b. Cob is a coarsely textured material containing many pore spaces, and capillary movement of moisture is very restricted. Tests have shown that vertical movement of moisture in an un-rendered cob wall will not normally exceed 150 to 250 mm. This means that injecting a chemical damp-proof course into the base of a cob wall may well be ineffective because, provided the cob is covered in a moisture-permeable render, moisture will not rise to the point where it becomes a problem. Moreover it should be emphasised that this method of damp-proofing, while usually successful in brick and solid masonry walls, is unlikely to be wholly effective in old random stone walls because of the large number of voids that often exist within their rubble-filled cores.

PENETRATING DAMP

Many cob walls were not originally rendered and provided that they are protected from erosion there is no necessity for render because moisture will evaporate very quickly from an exposed cob surface. Nevertheless, it has become general practice to render cob buildings and if this is done in the traditional manner with lime render applied directly to the cob, this will maintain and enhance the gentle undulations, variations in thickness and rounded corners which give rural cob buildings their unique character and charm. However, commonly when

rendering cob walls today attempts are made to square them up, particularly by the use of chicken wire or metal lathing and angle beads, all of which are then covered in a thick coat of cement-rich impermeable render which not only detracts from the building's appearance but can also lead to potential damage. Cement rendering can increase the weight of the wall by as much as 7.5 - 10% and, apart from over-loading the cob, its application can cause problems for two further reasons. Firstly, because these materials form a hard, impervious coating, they prevent excess moisture evaporating from the wall. Secondly, they have poor qualities of adhesion and,

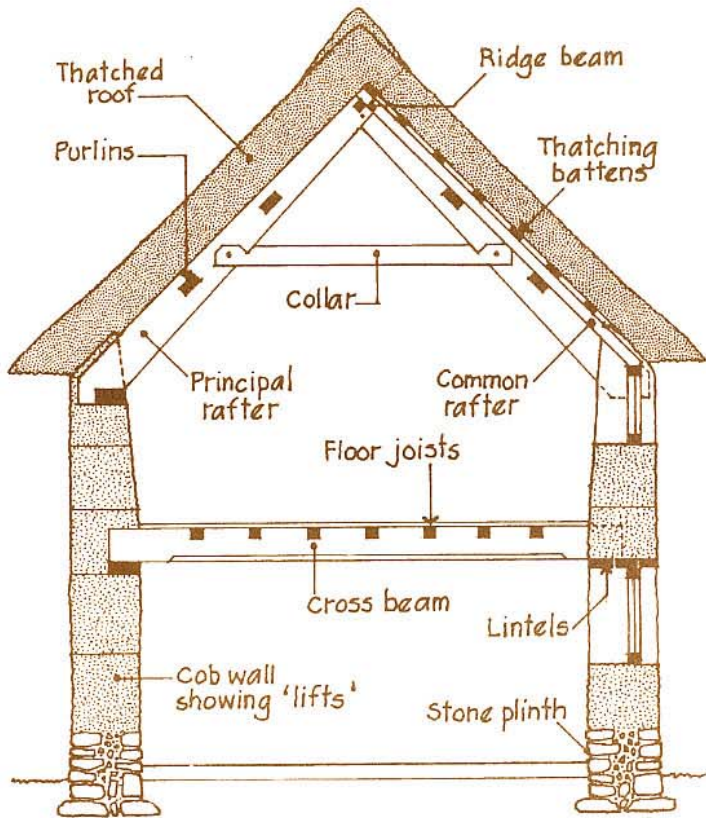


Fig.1. Cross-section through typical 17th century house.

being inflexible, are unable to accommodate to minor thermal and moisture movements in the wall. The most usual way in which these problems manifest themselves is when the cement render parts company with the cob and at the same time develops hairline cracks. Rain water penetrating the cracked surface is unable to evaporate and will, over a period of time run down the cob and soak the foot of the wall. It is at this point that the wall carries its maximum load - the weight of the cob above plus that of the roof - and is therefore most vulnerable.

Such problems of water penetration can readily be avoided or rectified by the use of a properly applied cement-free traditional lime and sand render. The same problems may occur inside the building, as most modern internal finishes seek to provide a completely impermeable lining to the walls. Lime plasters are the solution again and these should be decorated with distemper or limewash, not with emulsion paint or vinyl wallpaper, so as to allow the walls to breathe. Applying tar bands externally to the lower part of rendered cob walls is not recommended as this does not appear to be a particularly ancient practice and will tend again to impede the evaporation of moisture.

The subject of plasters and renders for cob and masonry walls is dealt with in detail in a leaflet published by Devon County Council and the Devon Earth Building Association entitled 'Appropriate Plasters, Renders and Finishes for Cob and Random Stone Walls in Devon'.

CAUSES OF DECAY AND STRUCTURAL FAILURE IN COB BUILDINGS

While structural faults in cob, particularly cracking, can appear alarming, they are often not as serious as they may look and can be remedied without recourse to extensive rebuilding or reinforcement.

Movement, cracking and fracturing and decay in cob walls can result from:

- i) Spreading of the roof structure as a result of insufficient ties across the trusses, or the decay or fracture of roof trusses, particularly when overloaded by too great a thickness of damp thatch.
 - ii) Racking (leaning towards the end of the building) of roof timbers for similar reasons as above. This may result in the forcing-out of the gable end walls.
 - iii) Movement in the stone plinth caused either by ground settlement (fairly rare) or by failure in its core which is often only composed of earth or rubble.
 - iv) Neglect of thatch allowing rainwater into the wall head, resulting in (a) the decay of the truss and rafter ends and (b) soaking of the cob, so reducing its load-bearing capacity allowing the truss and rafter feet to sink. In cases where walls are unrendered, water running down the wall face will cause localised erosion.
- Similar problems will occur in slated or tiled buildings where gutters and down-pipes are blocked or broken and overflow.
- v) Raising of the external ground level above the stone plinth, allowing the foot of the cob wall to become permanently damp, thus weakening the wall and reducing its load-bearing capacity at the point of greatest load.
 - vi) Dampness in the stone plinth causing moisture to enter the foot of the cob wall through capillary action. This is only a major problem where largely impermeable renders and plasters have been applied.
 - vii) Rodent damage: generally a problem in barns where grain was stored or animals fed.
 - viii) Abrasion caused by animals (movement and licking), machinery or vehicles: mainly a problem in unrendered walls.
 - ix) Erosion. All unrendered walls are subject to a certain amount of erosion which seems to be more of a problem in "dunland" areas (the grey and buff soils overlying the Culm Measures). The rate of erosion would

seem to be no more than 25mm (1") over a 100-year period. More serious localised erosion can be found on corners and about 1 - 1.5 metres (3ft - 5ft) below eaves level on south and west facing walls, (particularly where there are no gutters) as well as immediately above plinth level and between lifts, where horizontal fissures are sometimes found.

PRINCIPLES OF REPAIR

Unlike stone and brick walls, which are made up of numerous small individual units set in a matrix of clay, lime or cement mortar, cob is a homogenous material formed en masse. Not only do cob walls behave in rather different ways to those constructed of masonry, but when faults develop, they also require a rather different approach to structural repair and reinstatement.

Contrary to popular belief, cob is an inherently stable material, provided it is kept dry, and will tolerate a great deal of abuse. Because cob walls are usually at least 500-600mm (18-24") thick, surface erosion is not normally a serious problem. An additional advantage of such thick walls is that 'stitching' across cracks and fissures to achieve an efficient mechanical joint is relatively easy, as is the reinstatement of the cavities and hollows that can result from more serious erosion, abrasion or minor damage. Attempts should never be made to realign leaning sections of cob walls by the use of hydraulic jacking or levering devices. Walls must always be stabilised or consolidated as they stand, except in cases where an unacceptable degree of outward lean has developed. It is always advisable to check the verticality of cob walls inside as well as out because apparent leaning may be deceptive, being the result of out-of-plumb building or 'slumping' during construction. In cases where outward lean exceeds the safe limit, and is combined with severe cracking, careful dismantling and rebuilding may be the only answer. The philosophy of minimum intervention advocated for many years by the Society for the Protection of Ancient Buildings is one which is particularly relevant in the case of cob repair. The aim should always be to repair and consolidate without causing physical disruption so as to ensure long-term stability and optimum performance. Guidance as to how this may be achieved is given in the following sections. However, it must be emphasised that practical experience in the field of cob repair is still fairly limited, which is why general rather than specific advice is offered.

MATERIALS FOR REPAIR

In recent times, cob walls have been repaired or altered using stone or brick rather than earth. This is primarily because shrinkage of new cob has always been recognised as a problem in bonding new work to old and, secondly, because it was usually considered more expedient to carry out a masonry repair. Unhappily, it is a fact that many of these often clumsy and inept repairs have resulted in major structural problems and occasionally actual collapse.

Repairing a cob wall with stone, brick or concrete blocks set in cement/sand mortar may be compared to mending an old, worn garment with a strong leather patch. The long-term effects are likely to be equally disastrous because in many

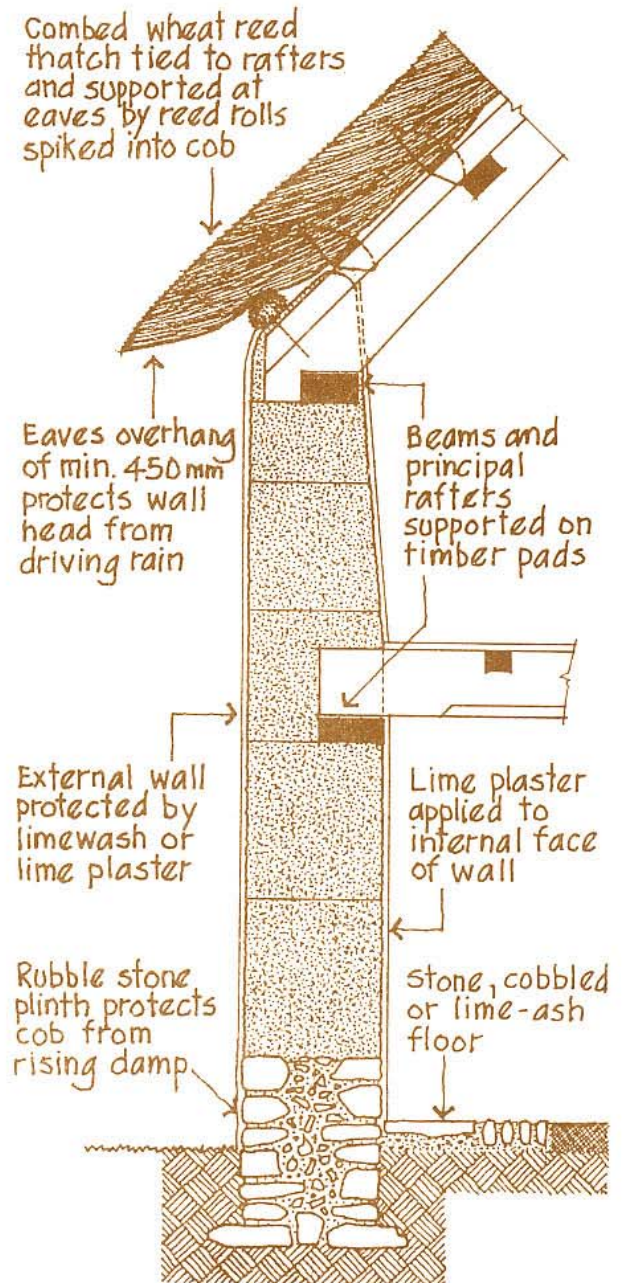


Fig 2. Enlarged cross-section through unaltered cob wall showing construction details.

respects these hard, inflexible materials are incompatible with cob. It has been noted that, in order to perform efficiently, cob needs to be able to shed excess moisture freely. One effect of inserting relatively impermeable materials into cob walls is to impede the free movement of water vapour, thus concentrating excess moisture at the interface between the two materials. Structural failure could well occur at this point because of the build-up of moisture levels, especially when there is a poor bond between the inserted masonry and the cob, and where there is a strong impermeable external cement render. The strength of cob walls which have in the past been repaired or partly rebuilt using stone, brick or blockwork is much reduced and they are consequently more likely to fail when subjected to undue stress.

Timber is probably the only structural material that can be regarded as compatible with cob because it is both flexible and vapour-permeable, while having a greater strength-to-weight ratio than both mild steel and reinforced concrete. In

addition to these qualities, oak in particular, is very durable and resistant to decay. For certain types of structural repair the use of timber is obviously essential and its advantages as a substitute for concrete and steel for structural repairs to cob buildings are not perhaps sufficiently recognised.

Clearly, the most appropriate way to maintain the structural and historical integrity of cob buildings would be to carry out repairs using the original raw materials; sub-soil and straw. Until recently, however, problems associated with the drying-out shrinkage of wet cob and the difficulty of bonding new work to old have acted as a deterrent to the use of earth for repair and reconstruction. In fact, recent experience has shown that these problems can, to a large extent be overcome and some suggested repair methods, using earth in various forms, are discussed below.

Suggested Repair Methods

Research and field testing has been carried out into repair methods based upon the use of cob, in both raw and lime stabilised form, which are considered more appropriate and certainly less disruptive than those using other materials. Because cob lacks the necessary tensile strength to form an efficient mechanical joint, it is considered prudent to incorporate some form of non-ferrous metal reinforcement in cases where the possibility, however remote, of further movement may exist. Some suggested repair techniques are described in the following section, but only in outline in order to provide general guidance.

Structural repairs to roofs and stone plinths, which may need to be carried out as part of a programme of remedial works,

are beyond the scope of this leaflet; so also is the question of the need for major, potentially disruptive and damaging works such as underpinning and buttressing. In certain cases such drastic intervention may be justified. Sometimes, however, this type of repair is specified as a precautionary 'belt and braces' measure, which may not only be unnecessary but may even, if carried out ineptly, lead to further structural problems. Where some doubt exists, advice should be sought from the organisations listed at the end of this leaflet.

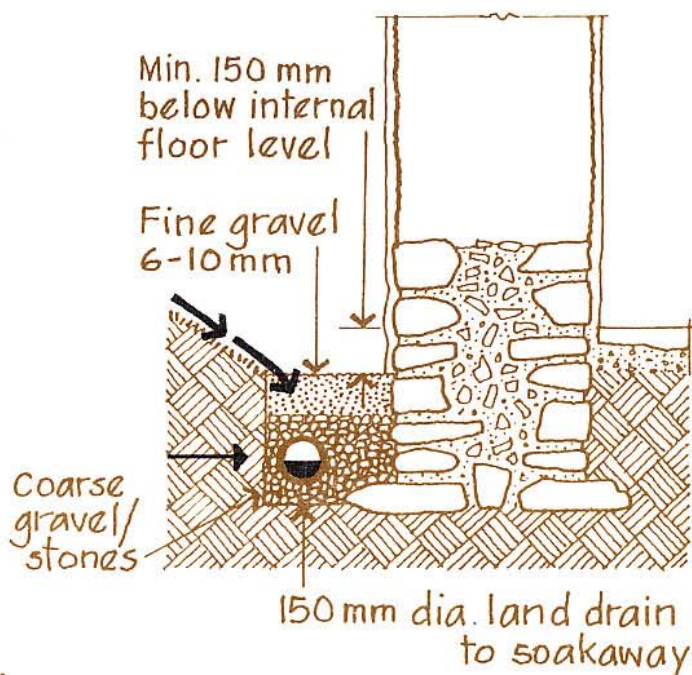
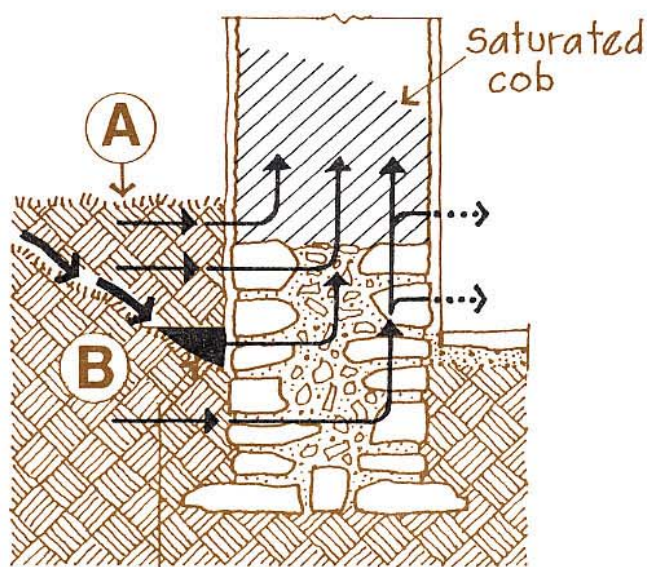
Reconstruction of sections of wall which have to be taken down

Problems which need to be overcome are those relating to (1) shrinkage of new cob and (2) the need to form a mechanical key between old and new material.

Shrinkage, which occurs in almost all soils that contain clay, has been found to vary from around 1.5 to 3% (15 to 30 mm over a one metre length) and occurs both horizontally and vertically. The faster a section of wall is built the greater will be the vertical movement, or settlement, because successive lifts will increase the weight bearing on those below. To a certain extent this problem can be overcome by allowing sufficient time for each lift to dry out, but a certain amount of settlement is bound to take place. The soils most subject to expansion and contraction are those which contain a large proportion of fine clay. Shrinkage in such soils can be reduced to manageable levels by the simple expedient of adding sand or by blending with a sandy soil containing only coarse clays. Shrinkage may also be reduced by using a drier mix heavily rammed in shallow layers between shuttering (a technique more akin to pisé de terre than traditional cob construction).

Fig. 3. Moisture penetration resulting from (A) raised ground level at foot of wall or (B) wall construction at bottom of gradient.

Fig 3b. Alleviation of damp problems by improved drainage.



Standing water

- Capillary moisture movement
- Running water
-→ Water vapour

According to contemporary accounts, from the middle of the 19th century it became common practice in some parts of Devon to add lime to cob mixes, presumably in order to expedite the building process. However, recent experience would indicate that for new building, or for the reconstruction of large sections of cob wall, it should rarely, if ever, be necessary to add stabilisers to the soil. The use of lime may, however, be justified in certain cases as a means of controlling shrinkage when carrying out minor repair works (see following section). The addition of 5 to 10% non-hydraulic lime to the mix can reduce shrinkage by up to 50%; it will help the material to achieve a faster set and, ultimately, greater strength. The precise proportion of lime to be added would depend on the clay content of the soil. The use of Portland cement is not recommended as the material is considered to be too strong for use with cob and fundamentally alters the nature and structure of the soil.

When rebuilding a section of cob wall it is best to avoid stepped joints (see Fig 4.1) because these will encourage the formation of cracks. Joints between old and new cob should be either vertical or sloped in order to allow for settlement and shrinkage of the new material. In vertical joints settlement can be provided for, while maintaining a mechanical key between the new and the old cob, by the incorporation of a hardwood tenon or shear key (which may also serve as a structural full-height wall post supporting rafters or wall plate). Any shrinkage cracks that develop may be filled by ramming in dampened sieved cob with a steel rod or similar tool. In cases where large sections of wall have collapsed, main floor beams and principal rafters will require structural support. Wall plates should be formed in oak rather than reinforced concrete, and beam ends can be supported on oak posts, masonry or stabilised soil blockwork pillars. For structural repairs the advice of an engineer, surveyor or architect should be sought.

The repair of cracks and fissures

In the majority of surviving Devon Cob buildings the walls form an integral part of the structure and are fully load-bearing. Because the tensile strength of cob is relatively low, any significant movement in either the roof structure or the stone plinth is likely to result in the development of cracks and fissures in the wall. In the most common form of failure, the gable wall will become detached from the lateral walls. (see Illustration). Full-height cracks will appear which become progressively wider as they near the top of the wall - an indication that the wall is being pushed out by the roof timbers - in the illustrated case as a result of 'racking'. No attempt should be made to repair a structural crack unless the wall is known to have stabilised and there is a reasonable certainty that all movement has ceased.

There are numerous examples of buildings where, in the past, structural cracks have been 'repaired' by simply ramming in masonry bedded in cement mortar, which was then concealed under a hard cement render. Such an approach to the problem may actually increase the risk of serious structural failure in the future - a case of the cure being deadlier than the disease. When cracks and fissures develop in a cob wall, what was formerly a homogeneous, monolithic structure becomes separated into two or more massive slabs of material, each weighing many tonnes. An effective repair is one which provides an



Typical structural crack in cob wall.

efficient mechanical joint between detached sections of cob, allows for continued minor movement within the wall, does not impede free movement of moisture and has physical characteristics compatible with those of cob. These requirements clearly cannot be met by the use of concrete, brick or masonry set in mortar, as the resulting stitch will be too inflexible and too impermeable to moisture.

Instead two basic methods of crack stitching, which may be modified to suit individual cases, are suggested: (1) repair using pre-cast cob tiles or cob bricks/blocks, with reinforcement incorporated if required (2) the ramming into pre-cut chases of stabilised cob incorporating metallic or fabric reinforcement. Both methods are shown in Fig 4. The method to be adopted will depend on the location, severity and extent of damage. For example, a structural crack that has been widened as a result of long-term erosion by running water will require extensive rebuilding, so the use of cob tiles or blocks would be the obvious choice. It should be noted that cracks, especially those occurring at wall junctions, will not always be at right-angles to the wall face but may run diagonally (see Fig 4.4).

The first method largely overcomes the problems of shrinkage associated with the repair of old cob with new by using cob bricks, tiles or blocks. These can be fabricated to any desired size using bottomless timber or metal moulds. Manually-operated concrete block-making machines can be adapted for use with cob, and portable block presses, also manually operated, are available. For crack stitching, cob tiles are considered most suitable because they offer a high degree of flexibility and are easily handled. Cob tiles or blocks are laid in bonded courses, in pre-cut horizontal chases, using a technique similar to that of conventional masonry construction, in a mor-

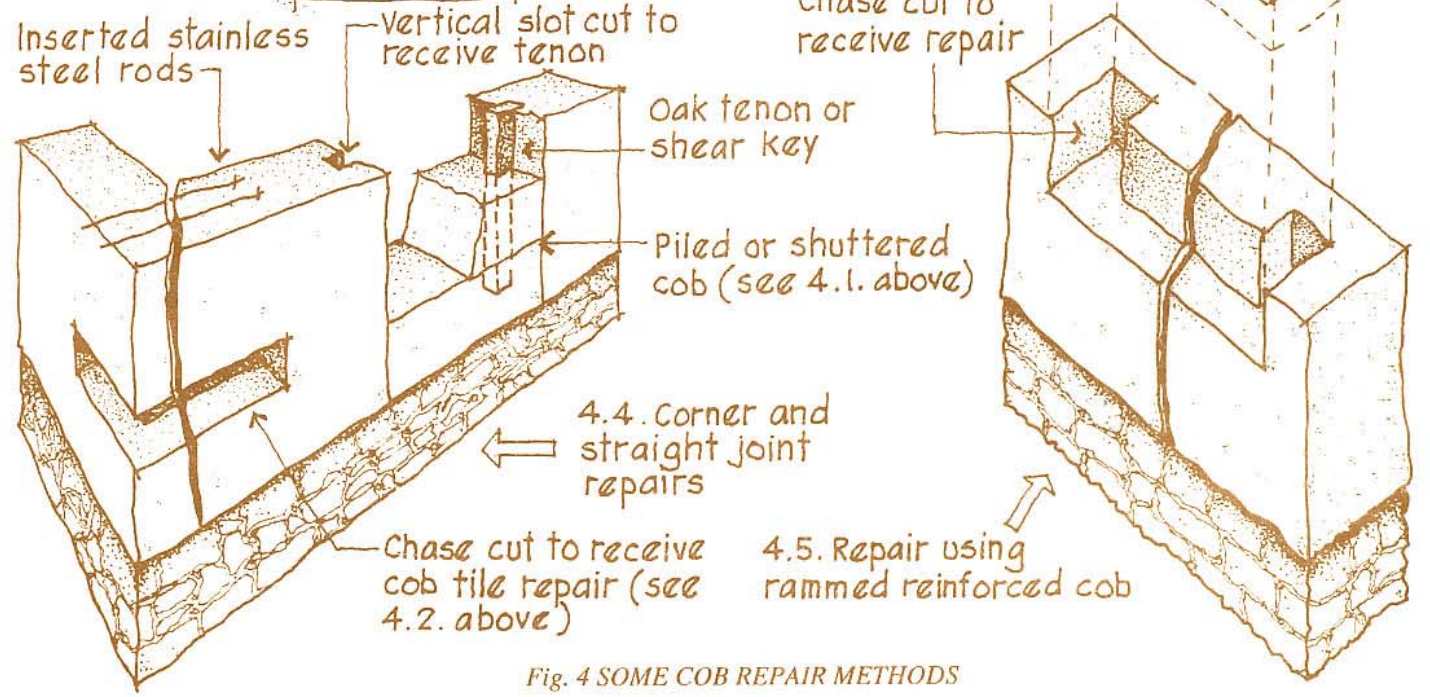
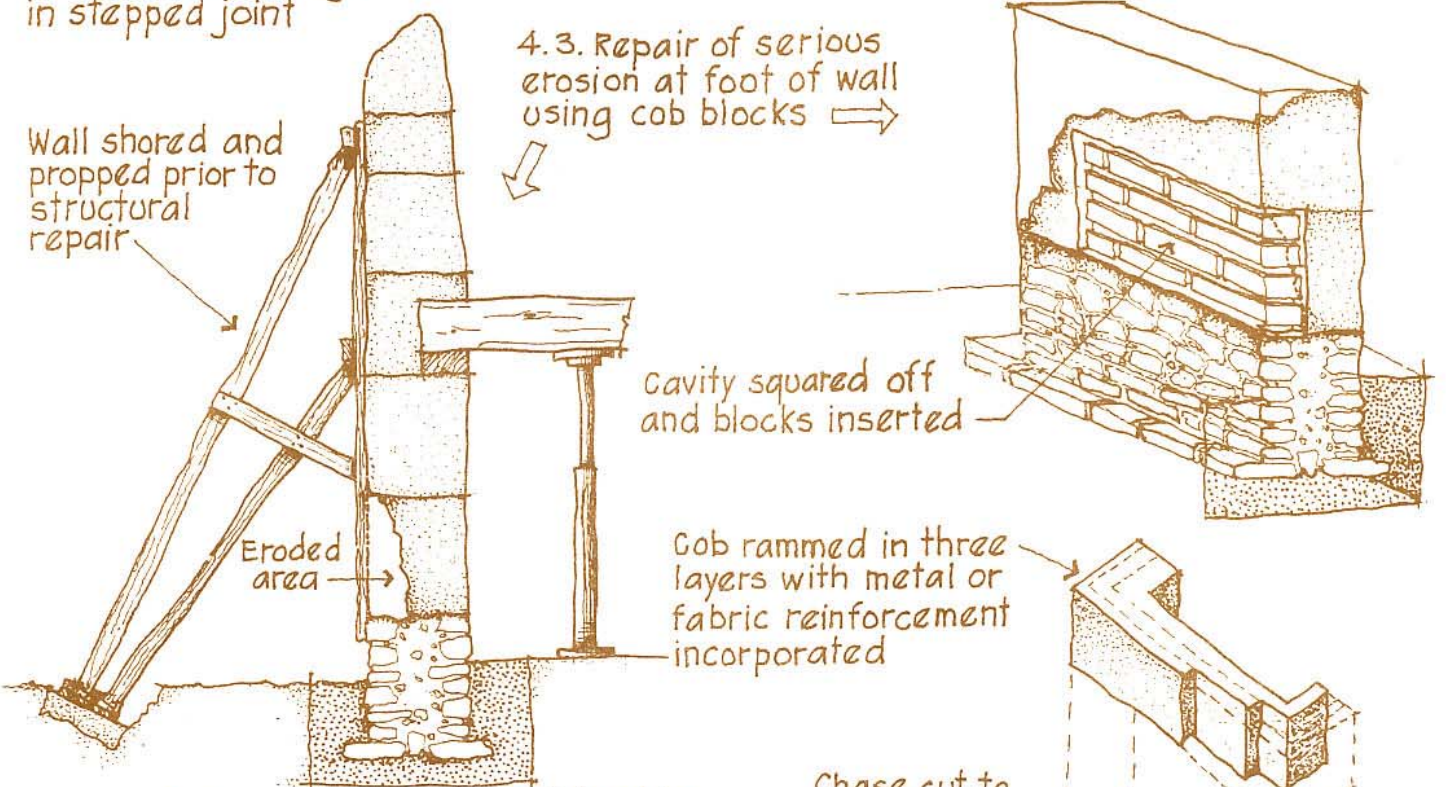
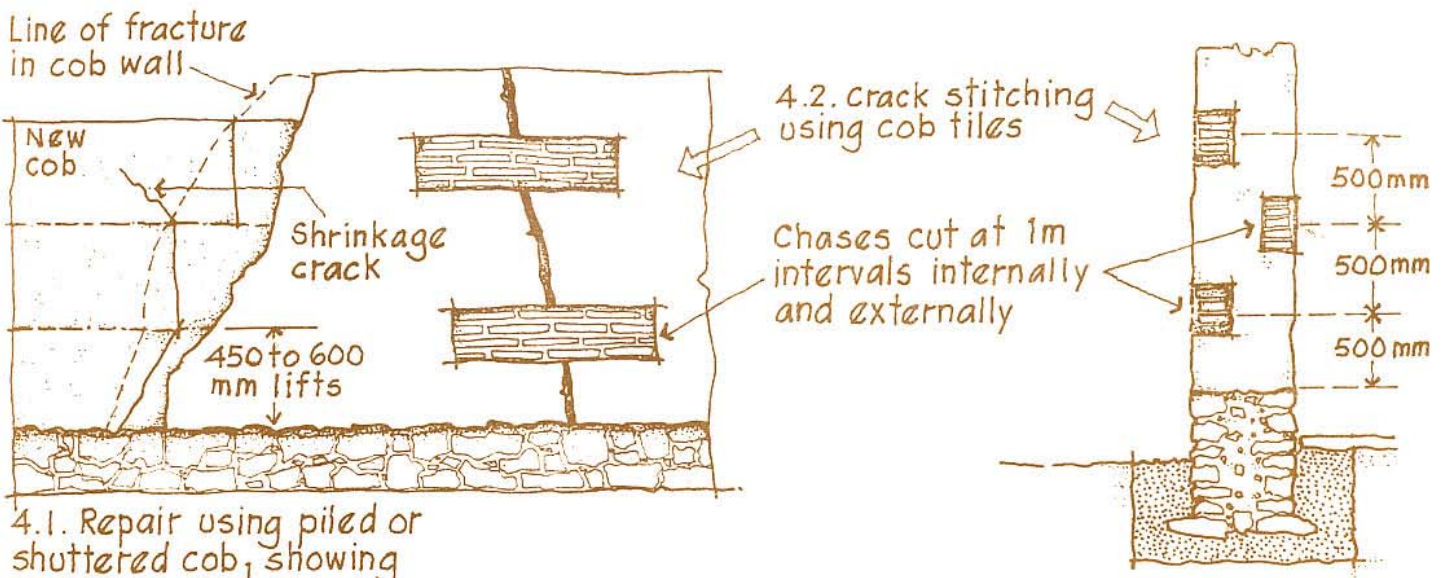


Fig. 4 SOME COB REPAIR METHODS

tar comprised of sieved sub-soil, coarse sand and lime putty. Non-ferrous metal lathing reinforcement can, if required, be laid between tile courses. When stitching is complete the remainder of the crack can be filled by lime/sand grouting or by ramming in a cob mix containing only enough water to achieve workability in order to reduce shrinkage to the minimum.

The second method of crack stitching, which involves the use of reinforced rammed cob, is probably less suitable for corner repairs but quite adequate for straight walls. It requires the cutting of chases as for tile stitching but with the addition of returns or rebates, usually cut to half the depth of the wall, at either end of the chase to help anchor the repair. Work proceeds in three stages, with the reinforcement being incorporated at the first and second stages (see Fig 4.5) A standard cob mix, including straw, but with the addition of 5 to 10% lime putty is used. The mix should be kept as dry as possible in order to minimise shrinkage.

Tests have indicated that secure fixings into cob walls can be achieved using helical stainless steel rods, the main advantage of which is that they can be inserted without pre-drilling - thus achieving an immediate fixing with minimum disturbance to the wall. This technique may lend itself to the repair of cracks close to corners (see Fig. 4.4) and would appear to have considerable potential, but it should be emphasised that it is a largely untried method and should not be used without first obtaining professional advice.



Crack stitching with cob tiles: Town Farm, Gittisham.

Repairs to cavities, hollows and badly eroded areas

These can be carried out using variations of the methods described above. In all cases it will be necessary to cut back the existing cob to accommodate the placing of new material. A flat, level base is essential and the sides and tops of cavities should be squared off or undercut. An effective mechanical key between old and new material can be formed using oak pegs, hazel spars, galvanised slab nails or non-ferrous metal connectors. Corners, door and window reveals and the buttresses found either side of threshing barn doors are areas particularly prone to erosion and abrasion. In these cases cob tiles or blocks may be the most appropriate method of repair.

Rodent Damage

Before rat holes and runs can be dealt with it is first necessary to trace their total extent and severity. Repairs have been carried out successfully in cases where damage is confined to a few tunnels deep within the wall and where all entry and exit holes can be identified by means of gravity or low pressure grouting using a mix based upon lime and sand plus suitable aggregates. Rodent damage can be very extensive and potentially destructive. Rat runs can extend through the entire depth of the wall, usually just above plinth level in barns where animals have been fed, for example. In these cases the cavities should be cleaned out, cut and squared off, then filled with either rammed lime-stabilised cob or cob blocks set in a mortar, as described above. Walls should be shored, and roof and floor loads supported internally while work proceeds in stages, around one metre of wall being dealt with and allowed to consolidate before the next section is commenced. Should there be any doubt about the stability of the wall where these works are proposed, it is essential that professional advice is sought beforehand.



Reconstruction of a cob wall using pre-moulded cob blocks at the Church House Inn, Stokeinteignhead. (Photograph published with kind permission of Architecton and Heavitree Brewery PLC).

Conclusion

It is hoped that the guidance provided in this leaflet will encourage owners, builders, architects and surveyors to adopt a much more conservative and sympathetic approach to the repair of cob buildings. Such buildings form an important part of our heritage. They have stood the test of time and need only to be treated with care and respect in order to serve many more years, even centuries, of useful life.

Anyone requiring further information, or seeking advice on the repair and maintenance of cob buildings, should contact their District Council Planning Department and ask to speak to the Conservation or Historic Buildings Officer. Specialist advice is also available from the following:-

*Countryside and Heritage Division
County Engineering and Planning Department
County Hall
Exeter EX2 4QW.*

*The Society for the Protection of Ancient Buildings
37 Spital Square
London E1 6DY.*

*Devon Earth Building Association
50 Blackboy Road
Exeter
EX4 6TB*

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