DISCUSSION OF REPAIR OPTIONS FOR MASONRY STRUCTURES, MALTON, NORTH YORKSHIRE

NIGEL COPSEY
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We place a strong emphasis upon the promotion of open, honest and unhierarchical dialogue between all those involved in a project, as well as engaging with the craft, history and cultural significance of the building or monument itself.

We believe that there are no circumstances in which the use of ordinary portland cement mortars may be either necessary or justified in the context of a structure not originally constructed using these materials.

We use lime mortars and traditional materials whose performance has been tested over centuries of use in all climates and conditions.

We believe that the skilled and informed use of traditional materials such as wood, stone, brick, lime and earth is not only good for the buildings of which they are a part, but good for the environment as a whole and for a healthy life in general.

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Passion and expertise in the care and repair of old buildings
This document represents a contribution to the discussion of issues relevant to the effective care and repair of masonry structures in the town of Malton, North Yorkshire. It has been written in the context of conservation and repair works carried out by myself for the Fitzwilliam Estate, and includes the report upon these. My approach to the works to the Talbot Coach House wall and to the lower level of the adjoining house has been to execute these in a manner which provides practical examples of available repair options and which will allow a longer-term assessment of these. I have also taken the opportunity to discreetly trial a variety of lime mortar designs, the relative performance of which may be assessed and compared overtime. It is my hope that this report/discussion document will contribute to the necessary evolution of repair strategies within the specific context of Malton in keeping with more general conservation strategies.

The objective conditions would seem to exist for the establishment locally of a well-articulated and thoroughgoing policy of care and repair within the town, to the enhancement of its aesthetic and commercial environment and to the well-being of its historic fabric.

The majority of the historic building stock of the town is in single ownership, and the owner is committed to the proper conservation of its buildings, utilising appropriate traditional materials (particularly lime-mortars) in a proper ethical and practical context.

Ryedale District Council, through the offices of its Conservation and Listed Buildings Officer, is supportive of this approach, and is a stakeholder, along with North Yorkshire County Council and English Heritage, in the Heritage Economic Regeneration Scheme.

Furthermore, the skills and the understanding necessary to carry out best practice conservation repair exist locally. Education and practical training is readily available and may be accessed easily and affordably by those local building contractors not already familiar with the proper use of traditional materials.

Experience in the South-West, and particularly in South Somerset demonstrates that a confident, dynamic and pro-active local authority conservation policy, coupled with a plentiful supply of specialist practical building conservation expertise locally leads to a much-increased awareness and take-up of (old) new skills on the part of local building
contractors formerly wedded to inappropriate and destructive ‘cement technology’.

Good quality lime, whether putty or hydraulic, is readily available within a 20 mile radius of the town.

Malton enjoys, therefore, a perhaps unique opportunity to become a regional exemplar of good and effective building conservation practice.

This document should be read in conjunction with Seamus Hanna’s ‘Report On The Approach To Preservation Of Stonework On Vernacular Buildings In Kirkbymoorside, Malton and Pickering, North Yorkshire’ for the English Heritage Building Conservation and Research Team.

Malton is constructed mainly of brick, sandstone and of two distinct types of limestone. Stone buildings are frequently built of a mixture of limestone and sandstone. Its builders commonly used plinths of local sandstone below mainly limestone walls, although free-standing boundary walls and houses are as often built entirely of sandstone. The majority of stone walls in the town have lower courses of sandstone and this presents notable patterns of decay, to a greater or lesser extent, throughout the town.

*Lower Castlegate*
The perceived aesthetic and structural problems associated with this decay have been addressed in a variety of ways over the years. There are examples of refacing of decayed wall-bases with brick, with new stone and with render. The renders used have been almost universally based upon ordinary Portland, or 'roman' cements. These are equally universally detaching and, if not loose, they are hollow and cracked. This material allows moisture into the already decayed substrate whilst at the same time preventing its ready egress. It introduces and traps damaging salts. It most certainly does nothing to enhance the structural qualities of the stone behind. There is a spiral of decay at work here, and certainly not the considered management of gradual decay as aspired to by English Heritage.

The majority of stonework in the town, whether to houses or boundary walls, has been repointed with ordinary Portland cement–based mortar, which is damaging to any masonry, and especially so to relatively soft and/or decaying stone or brick. Not only the material, but the method of this repointing work is damaging and more likely to promote than to inhibit decay: more recent pointing is most commonly of a ribbon/strap type, standing proud of the stone substrate, presenting a matrix of ledges to collect water before channelling it into the building. This moisture then finds egress impossible except via the stones themselves,
and this more slowly than would be the case via soft lime mortar joints, promoting frost damage and the concentration of salts which will crystallise in drying conditions just behind the face of the stone, progressively bursting it away.

Throughout the town, the enhanced decay of lower courses of sandstone to a height of between 2 and 3 feet is notable. Plinths of other materials, whether brick or limestone have not decayed to anything like the same extent. Such decay as there is to brick or limestone plinths may be confidently ascribed primarily to the effects of ill-advised opc mortar repointing and to acid attack from vehicle exhausts.

*Typical roadside plinth decay, Yorkersgate*

The decay to sandstone plinths is not universal, however. With hindsight, of course, it is possible to assert that the stone was ill-chosen for its purpose. However, many of the most decayed plinths are of large bed-height and of large dimension generally. In the case of the Talbot Hotel Coach House Wall, it is at least possible that these stones were recycled from the mediaeval town wall, which stood close by. It is quite possible that the Old Lodge Wall is either a remnant of the castle precinct, or is constructed of stones recycled from the castle itself. These stones may
have been out of the ground for longer than most, therefore.

What would seem beyond doubt is that the decay of sandstone plinths throughout the town is particularly associated with damage by salts. Added to this is a general vulnerability of calcareous sandstone to decay induced by acids, particularly form nitrogen compounds produced as a result of the burning of fossil fuels, whether coal, gas or petroleum products such as petrol and diesel. Ordinary Portland cement is rich in sulphur, and the repointing of sandstones with opc mortar will have accelerated the consequences of acid and salt attack.

The general source of salts within masonry structures is from the ground. Very many of the decaying sandstone courses are not only on the ground, but retain ground, and the abundance of salts is therefore inevitable. Many of the plinths carry limestone masonry and are therefore at least in theory vulnerable to decay mechanisms associated with this association (see Hanna). I am not convinced, however, that this is a significant decay mechanism in this instance.

There are many plinths of like sandstone that present no decay comparable to that of the Coach House Wall, for example. Similarly, there are many sandstone plinths that are vulnerable to ground salt migration that do not display any comparable decay, or, indeed, any more decay than sandstones at higher levels in the building, well-away from the reach of ground-salt migrations. There are also buildings in the town that are built with a mixture of local lime and sandstone, the church being a prime example. Sandstone below limestone on the tower of the Church of St Leonard’s with St Marys shows no different a pattern of erosion to sandstone above or well away from this limestone.
Mixed lime and sandstone, south wall, tower, St Leonards Church
In situations where a sandstone is vulnerable to calcium carbonate, decay tends to be particularly evident in the sandstone immediately below the limestone. Such vulnerability manifests in the arrisses of sandstone at the joints also, since, of course, the original bedding and pointing mortars are of lime mortar. The combination of lime and limestone dust in a mortar creates a calcium carbonate material chemically very similar to limestone. It is a characteristic of historic mortars locally that they contain a high proportion of limestone dust. If the local sandstone was vulnerable to decay by proximity to calcium carbonate, then one would expect to see a pattern of significant arriss decay across the whole range of walls and buildings in the town, as is the case in Worcestershire, for example, with or without the presence of limestone in the building. This is clearly not the case. The majority of arriss decay in the town is associated with the inappropriate use of ordinary Portland cement–based repointing mortars and more gradual powdering associated with atmospheric sulphur and carbon compounds.

The sandstones of the Vale of Pickering are Calcareous sandstones of varying silica content (the silica content of samples examined by Jefferson Consulting varied from only 27% in stone from the Old Lodge Wall,
Malton, to 57% in stone from Park Street, Pickering). As suggested by their yellow colour, they contain iron. The primary binder of Calcareous sandstone, however, is calcium carbonate. This makes them vulnerable to decay by airborne acids, in similar ways to limestones, although the patterns of decay in limestone and sandstone will manifest differently. It makes it highly unlikely that the proximity of calcium carbonate in the form of limestone is a likely primary cause of decay, since local sandstones are themselves rich in calcium carbonate. The relatively low calcite content of the Jurassic sandstone around Whitby, and the results of tests on historic sandstone in the Vale of Pickering suggest that there is a decreasing silica content, and therefore an increasing proportion of calcite (CaCO3), north to south, with the sandstones of the Malton area having a high CaCO3 content.

It would seem clear to me that the high levels of degradation to sandstone plinths in Malton is associated primarily with splash from rock-salted roads, with associated decay caused by high concentrations of vehicle exhaust gases at lower levels. Wherever plinths are defended by distance or elevation from road-splash, or less heavy concentrations of vehicle exhaust emissions, they show little differential decay to the rest of the elevation. Wherever they are vulnerable, and particularly on the roads that have the greatest volume of traffic travelling at the greatest speed, there is significant decay. The regular and frequent saturation by salt-laden water of walls that have been pointed with hard and impervious opc-based mortars has disproportionately exposed the vulnerability of the local sandstone to decay, incorporating other decay mechanisms such as frost in a devastating alliance.
Inspection of patterns of decay to the Old Lodge Wall shows that the decay to the road-side of the wall is much more extensive, and of a different pattern to that on the Hotel side. The inside face has relatively even decay, with none of the undercutting particularly at lower levels evident on the outside face. Given that the inside is the southerly elevation, one would expect more erosion on this face, due to its greater vulnerability to the damaging effects of freeze/thaw cycles during the winter. The Estate Offices, remnants, along with the Old Lodge Wall of the Jacobean house, which are set back from the road and the plinths of which are at a higher level than the road show similar patterns of decay to the inside elevation of the Lodge wall, and none of the undercutting evident to the outside of the Lodge wall.
Old Lodge wall, south side
Buildings in the estate yard, well away from road splash and heavy concentrations of exhaust gases show even and gradual erosion across their entire elevations, despite having been repointed with hard cement mortars.

Outbuilding, estate yard

Regarding decay associated with the burning of fossil fuels, this is summarised succinctly by Honeyborne:

“A small minority of sandstones used for building in the UK are cemented by calcite (calcareous sandstone)... These sandstones weather more severely than limestones in regions of high air pollution because the dissolving of a small amount of calcite will release many sand grains. Where the stone is heavily rain-washed, the surface will steadily powder away. When the stone is not heavily rain-washed, the acids attack some of the calcite converting it to the more soluble gypsum. Some of the gypsum is drawn towards the surface in solution and redeposited as the moisture dries out again. This produces a weakened layer roughly 4mm below the surface of the stone which blocks the pores of the surface layer. As the temperature varies, the unrestrained gypsum expands or contracts about 1.7 times as much as sandstone. Changes of temperature will therefore create stresses that tend to break the gypsum–rich layer from the underlying sandstone.” (Weathering and Decay of Masonry, Ch
Wind will amplify this cycle of decay, creating patterns of greater erosion to the more exposed areas of a structure, even to the more exposed parts of individual stones (as may be seen on the Vanbrugh Arch and the piers of the Old Coach House Wall). Wind is not in itself the cause of the decay, insofar as the erosion is not caused by windborne abrasive material.

I would reinforce Hanna’s assertion that the use of silane-based stone consolidants is uncalled for in the context of Malton. The Society for the Protection of Ancient Buildings maintains a moratorium on the use of such consolidants and research by Dr Clifford Price suggests that the likely depth of penetration is actually minimal. In circumstances where moisture is absorbed into the stone from the ground below or behind the stones, then a consolidated (evaporating) face would likely accelerate rather than slow decay of the stone. The use of water repellants should never be allowed upon porous masonry. These will lead to a rapid degradation of the faces of the stones, compounding the problem they are offered as solution to.

The earlier use of lime mortars for repointing and, even, for rendering work would have reduced the impact of road salt damage considerably. It would also have reduced the vulnerability of the masonry to the sulphur-soluble gypsum cycle. Lime mortars allow ready breatheability as well as providing sacrificial poultices for salts. I would hazard that the levels of decay to these stones has accelerated dramatically since the introduction of road-salting, Portland cement and the increase in car and lorry volumes.

Also associated with road traffic is the heavy sulphation of limestone in walls alongside main roads in the town. Yorkersgate and Castlegate are used by around 100 HGVs daily. Traffic is frequently slow-moving on both roads. The buildings in Castlegate are heavily discoloured by diesel particulates, which dust their entire elevations. This is aesthetically displeasing and unhealthy; the sulphation-crusting of limestones causes their progressive decay. The Coach House wall has thick crusts in many places; where it does not it is because these crusts have blistered and detached, taking significant volumes of stone with them. These sulphation crusts will re-establish over time. The Vanbrugh Arch is heavily soiled with such crusts and has suffered significant decay and loss of detail at least partly as a result.
There are three main strategic decisions that would have greatest positive impact upon the levels and rate of decay in Malton:

1) Use only lime mortars (which means mortars with ZERO ordinary Portland cement content) in repair and repointing works, and promote a policy of removal of opc repointing work as a matter of priority;

2) Significantly reduce the impact of road-salting. It may not be possible to stop salting roads (although climate-change may reduce the necessity over time). However, a significantly reduced speed limit through the town would reduce the range of splash, as would regular maintenance of drains (many of which are currently full of leaves). Any reduction in traffic volumes would be of benefit to the historic fabric of the town.

3) Take steps to remove all but essential HGV traffic through the town. The existing by-pass does not do this, or, at least renders it necessary for HGVs heading into Norton to pass along Yorkersgate and Castlegate.

REPAIR OPTIONS

Although the sandstone locally is prone to significant decay in certain situations, it retains good compressive strength and structural integrity behind the loose or powdering surface. Generally, the stones that show the most pronounced decay are large and extend a long way back into the wall.

As stated by Seamus Hanna, the presumption of any repair strategy should be intervention to the minimum necessary to slow the rate of decay as far as possible whilst at the same time maintaining overall structural integrity of the wall or building. Extensive stone replacement would be hugely expensive, even if a compatible stone could be found. The basic soundness of the stones that might be candidates for replacement means that any full-depth replacement would be hard-going, time-consuming and the brute force involved would carry a significant risk of disrupting the surrounding masonry. Facing up the plinths with a partially structural facing of new stone would be to invite an enhanced risk of structural disruption or failure in the future and cannot be justified on the grounds of ‘taste’ alone. New stones alter the
overall character of a weathered and eroded wall considerably, especially where the weathering takes the form of a rounding of the old stone to its joints. Whilst the use of pitch-faced replacement stones reduces this effect, it is by no means certain that the original profile of the masonry was pitch-faced. It is also common for stone-facings to lack adequate back-filling of mortar, even with the best intentions of the mason. It is difficult for them ever to receive normal loading from the masonry above (unless this subsides onto them) and there is always the possibility, therefore, of their ‘popping out’ in time. There will be occasions when the insertion of new stone will be considered necessary or desirable. My feeling, however, is that in general this offers the least satisfactory option. It works best when the stone around it is only minimally weathered. Using it in this circumstance begs the question as to whether or not it was structurally necessary. There are decayed plinths in Malton where the decayed stone is itself a facing to the original masonry, using sandstone from without the Vale of Pickering.

Whilst gritstone from West Yorkshire has fared very well (almost too well, since it has reduced very little and feels quite at odds with the local materials), replacement stones from the Whitby area would seem to have decayed even more readily at lower levels than the local sandstones. A better case for replacing these replacements with further facing stones can be made than for facing up original material in this way.

There are relatively few sandstone plinth stones that have been eroded to a depth such as to undermine the stability of the wall, or even of individual stones above. The sandstone plinths were often stepped out some 4/5 inches from the wall above. The centre of gravity of the walls above continue to bear upon sound stone: they are still fit for purpose. Patterns of decay vary one to another, resulting in a visual chaos of decaying profiles. The initial, unconsidered perception is that these walls are more precarious than they are in fact.

The erosion and decay is progressive, however, and there will come a point when the structural integrity of otherwise sound walls will be compromised. This is becoming the case in parts of the town, where walls were built in a single plane, without projecting plinths.

Tidying up the reading of these walls and slowing the processes of decay would be compatible and complimentary objectives.

It is my opinion that this could best be done with a combination of repair techniques based upon the use of lime mortars. The objective would be
consolidation of the substrate using relatively discreet but honest repair methods.

Defrassing of loose material and the removal of opc mortar should be followed by an assessment, stone by stone, of the risk factors in further decay. Any significant areas of undercutting might be filled with a stone or clay tile repair. This may involve a limited amount of chiselling away of original material to provide a flat base or a key for tiles of variable depth (the introduction of stone facings requires the removal of far more sound material and is more aggressively disruptive of the surrounding wall). Tile repairs are built up in thin layers, allowing for reliable consolidation of the mortar placed around and behind the tile. They are flexible, and may be contoured to blend in profile with the profiles of adjacent stones. Alternatively, they may provide a good key or termination for mortar or render repairs to less heavily decayed adjacent stones. The use of handmade clay tiles is considered by some to be a little obtrusive. However, it is my conviction that they effectively demarcate or signify areas of repair in a transparent but generally satisfactory manner. They are generally far less obtrusive in practice than new stone and are aesthetically pleasing in themselves. They are relatively soft and flexible.

There is an increasing tendency in stone conservation practice to substitute stone for clay tiles. These are used at 1 inch thickness, or thinner if practicable. It is difficult to saw sandstone reliably at less than this thickness. A hand–made clay tile has a beautifully varied but relatively straight edge, with a lot of character. Stone tiles have a sawn profile, which has much less inherent character, but which is not always unsuitable.

An advantage offered by tile repair is the provision of multiple lime joints which will enhance the breatheability of the wall–face, speeding the drying and evacuation of salts. The lime face may decay sacrificially, but is readily repointed should this occur.

In association with lime–pointing and tile repair, discreet consolidation of the stonework should be carried out using lime mortar. Voids and water–traps should be filled to maximise the shedding of water. Deeply eroded beds within certain stones may be filled out with a lime mortar of similar colour to the stone. Such ‘dentistry’ repair is a common approach in the South–West of England.

All of these procedures need to be executed with sensitivity and with the overall aim of maximising the longevity of the fabric without compromising its character.
THE TALBOT COACH HOUSE WALL.

Works to the Coach House wall were specified by Julie Smith of Lightly and Lightly to include repointing as necessary, the replacement of missing stones, the rebedding of coping stones and the rebuild as necessary of pillars that once held iron railings.

The wall is a retaining wall to its full height.

Repointing work was carried out in four slightly different mortars, offering an ongoing opportunity to monitor their relative performance. A fifth variation will be used for the repointing of the especially fine joints of the Vanbrugh arch. All mortars were lime mortars with the addition of no ordinary Portland cement.

At the same time, repair works were carried out to the lower section of the house that adjoins the site.

Repairs to the house wall included the replacement of 6 no. severely eroded stones (themselves refacings), removal of hard cement strap pointing and its replacement with lime mortar, as well as the lime rendering of more heavily eroded stone facings.

Eroded refacing stone, Yorkersgate

The section of wall between the house and its yard gateway had a badly...
One limestone refacing had lost all compressive strength and was removed. Stones above the base course were deeply eroded on their lower sections. The quoin had been previously rebuilt using small stones and a very hard opc mortar. The defective stone was replaced with a 4” deep facing of sandstone ashlar from the Blue Bank Quarry between Sleights and Whitby. The erosion to the stone above was repaired using sandstone tiles; the small quoin section was reformed with handmade clay tile. The deep erosion to the base stones to either side of the new stone was built up with lime mortar (with inclusions of clay tile pressed in to assist curing and to help key subsequent render coats. These stones, whilst deeply eroded, remained fit for purpose. Their effective refacing would have involved heavy hammering which might have unduly disturbed the wall, which is high but only some 4 feet long. The final coats of lime render were made up of sharp sand and Ancaster limestone dust at a 50/50 ratio, mixed 3 parts aggregate to 1 part HI2 natural hydraulic lime from Tout Quarry, Somerset. Although this is a 3.5 NHL, it delivers a significantly softer lime mortar than St Astier 3.5. It is also a cream colour, which is an advantage in mortar matching.
The intention of the lime render is to provide a sacrificial face to the base of a section of the wall particularly vulnerable to the effects of vehicle washed salts. The end of the adjoining building forms a corner and a water trap at the base of the wall.

One further clay tile repair was carried out further up the wall, where differential erosion in one stone had led to a severe horizontal undercut. The purpose of the tile repair was to pre-empt the detachment of the overhanging section of stone.
The limestone masonry was essentially sound and evenly eroded. Odd stones that had been laid face-bedded displayed somewhat deeper erosion.

Erosion to the freestanding piers above the wall was generally more
severe. The piers were constructed of the same local fine-grained limestone as the upper parts of the wall and the Vanbrugh Arch, but with gritstone capstones, probably from the Whitby area, possibly from West Yorkshire. These have weathered only minimally and may not have been original. The stones of the piers were originally masoned ashlar with precisely tooled margins. For the most part, this detail has been lost to erosion. The main mechanism of erosion has been wind, along with repointing in the past with a hard and dense ordinary Portland cement mortar, which has kept the stones wetter than would a lime mortar and more vulnerable to the actions of frost and wind. Upper courses of stone had been rebedded in opc mortar also, and capstones rebedded in the same.

The hard mortar had come loose long-since and was providing no adhesion between capstones or between the stones themselves.

The piers are none of them of exactly the same dimension, and never were. Those between sections 1 and 2 and between 2 and 3 were slightly rectangular on plan, the longest side running parallel with the wall. Others were square on plan. The pier caps had been made to measure. All piers have settled with the settlement of the wall beneath and none of them are in the same orientation as another. This differential settlement
is part of the character of any old structure.

The capstones were lifted off and the piers dismantled only insofar as individual stones were loose. The masonry of the pier cap between sections 4 and 5 was universally loose and had been disrupted by ivy roots in the past, its joints had accumulated organic matter to a full depth. This pier was dismantled to the top of the wall beneath and the stones set aside to ensure that each course returned in the same lay-out. All hard cement mortar was removed from faces and beds. The pier was rebuilt using a coarse lime mortar.

The patterns of wind-enhanced erosion made it very difficult to rebuild the piers reliably using a level; reliable reference points were hard to find. It was possible to align patterns of weathering between the lower edge of one stone and the upper of another. The objective was to follow the settlement of the base and to work mainly by eye, using a level mainly on the top beds. Taking the lead from the existing lie of the wall/sound section of the pier cap was essential to maintaining the piers' contribution to the overall character of the wall. It would have been a mistake, and more obviously contrived, to rebuild the piers absolutely plumb and true in themselves when the wall of which they are a part is none of these things.

The top two courses of the piers between sections 2 and 3 and between sections 3 and 4 were dismantled and the still sound courses below consolidated as necessary. It is notable that the main areas of disruption were those that had been rebuilt in the past using hard cement mortars. This had been unable to accommodate movement from below and had
left the stones loose, held in place only by the mass of the sandstone caps. The upper section of the pier between section 1 and 2 was very loose; a corner had been broken from the pier cap, suggesting a recent impact, since the damage is not evident on survey photographs. All piers were reassembled using a course lime mortar and were repointed using the same.

The sandstone plinth had been built with bed-joints generally no wider than 5mm. Perpendicular joints tended to be wider than this, and erosion had made them appear wider still. Pointing works kept to the original widths where appropriate. Elsewhere, pointing was laid in a little wider, to take account of patterns of erosion and to provide weatherings. Where larger sections of stone face were developing sheer cracks and where there were clear water traps, these were filled with lime mortar to provide weatherings. Large voids were packed with lime mortar and fragments of stone or tile and faced up with lime mortar.

The pointing mixes used were as follows:

To the house wall: 2 parts plastering sand (Walkers, York); 1 part limestone dust (Ryedale Conservation, Terrington); 1 part hl2, Somerset (supplied by Walkers, York);

To the lower section (Section 5, Smith specification): 1 part plastering sand; 3 parts sharp sand (Travis Perkins); 2 limestone dust; 1 part putty lime (Chalk Hill, supplied by Ryedale conservation); 1 part hl2;

To sections 3 and 4: 2 parts plastering sand; 3 parts sharp sand; 1 part putty lime; 1 part hl2;

To sections 1 and 2: 1 part building (soft) sand, 1 part sharp sand (both Travis Perkins), 1 part limestone dust, one part hl2.

To pier caps: 2 parts sharp sand; 1 part limestone dust; 1 part hl2.

The repointing mix for the fine joints of the Vanbrugh Arch were as for the house wall: 2 parts plastering sand; 1 part limestone dust; 1 part hl2.

General remarks:
In general, I would not recommend the use or inclusion of soft building sand in lime mortar mixes. It is not well graded, being comprised of grains all of the same size. It has no compressive strength. It is used in the building trade in the UK with ordinary Portland cement. Such mortars derive their compressive strength from the binder (opc). (In the USA, masons continue to use well-graded sharp sands even with cement, being more connected to craft tradition). Workers more familiar with using opc will tend to add too much soft sand to their mixes, so used are they to its use.

Lime mortars derive compressive strength from the aggregates used. It is essential, therefore, that aggregates are well-graded. Sharp and plastering sands are well-graded. Plastering sand is finer than sharp sand. Both resist shrinkage very well. The use or inclusion of soft sand promotes shrinkage.

The addition of stone dust may also promote shrinkage, unless it too contains a range of granule size. 5mm to dust is appropriate.

Initial slight shrinkage is not in itself a problem with lime mortars, as long as proper aftercare is carried out, and the mortars are recompressed, beaten back and moistened whilst still pliable. It is preferable to avoid shrinkage in the first place, however.

Abundant wetting of the substrate before repointing is a fair guarantor of low shrinkage and good adhesion of the mortar to the masonry substrate.

Mortars should hold the minimum amount of water necessary to deliver workability. Over-wet mortars will stain the stonework and be more likely to shrink. They will also be weaker. If the walls have been well-watered before work, and the new pointing is protected with regularly dampened hessian/burlap, moisture will diffuse through the mortar, promoting a gradual set, whether by carbonation or chemical reaction, or both.

The use of putty lime, with the addition of pozzalans is to be encouraged, as also the use of Natural Hydraulic Lime.

The gauging of putty lime mortars with up to 50% by volume of NHL is perfectly acceptable. The Smeaton Project found that a mortar made with a lime content 50/50 putty to NHL 3.5 produced a mortar with properties of vapour permeability and compressive strength similar to that of a putty lime mortar. The use of NHL, however, speeds the initial setting time and can offer advantages in terms of work speed and can reduce the timespan of a fresh mortar’s vulnerability to frost damage.
It is my experience that St Astier 3.5 delivers a mortar that may be too hard for use in repairs to soft and decaying masonry. There is a variability even in St Astier 2.0 that can at times see it being as hard in fact as a 5.0 NHL.

If St Astier NHL is used in the context of work within Malton, I would recommend that only 2.0 be used and that, even then, this should be gauged with 40–50% lime putty.

HI2, an NHL made in Charlton Mackerel, Somerset from Blue Lias limestone, although rated 3.5 delivers a mortar that is softer and more vapour permeable than that achieved with St Astier 3.5. It is in my opinion the more appropriate NHL for use in the Malton context. It may be used with or without the addition of putty lime.

For more general guidance on good practice with lime mortars, see attached texts below.
The Vanbrugh Arch provided access from the Talbot Hunting Lodge to the stables. It is a composite structure of stone and brick, although the stone archway is a self-supporting construction. It gives access to a clamp brick-built passage and gritstone paved stair.

The Arch is exposed to the prevailing wind and is effectively a wind tunnel. This has led to uneven patterns of erosion.

The arch is built mainly of local fine-grained limestone from quarries at Hildenley, near Malton, with a Whitby area sandstone plinth course. It has occasional insertions of local sandstone. All but one of these would have been unseen when the arch was built, but have been exposed by erosion of the limestone. One large block of local sandstone is structural and forms part of the rusticated jamb to the lower side. It is badly eroded to its face. This erosion is progressive and is both more extensive and more rapid than the ongoing erosion of the limestone. Its replacement represents a dilemma because the erosion of the limestone ashlar is significant. Its replacement with a piece of new limestone, or like-for-like would jar visually. It would be both difficult and affected to seek to artificially reproduce the pattern of erosion elsewhere in the archway in a new stone. No historic source for this limestone has yet been identified locally, although it bears a great similarity of appearance and characteristics (and I would hazard, geology) to base-bed Portland stone. It smells exactly as Portland stone does upon impact with a chisel, and responds to the tool in a very similar fashion. It is a different limestone to the dolomitic limestones used in York and sourced from Tadcaster and Cadeby. These have a different geology and quite distinct patterns of erosion, and should not be used in replacement work in Malton.

The arch stones were originally reticulated. The majority of this surface decoration has been lost to erosion. The pits of the reticulation, as well as all other sheltered parts of the archway have a sulphate crust, which is blistering and contributing to the decay of the masonry. The main body of the archway is built of the same limestone, in well-coursed dressed rubble.

The upper surface of the pediment has suffered extensive frost damage; large sections have delaminated; there are significant water-traps which will channel rain and snow melt into the body of the pediment and arch.
Pediment cap, lower side
There is extensive plant growth and consequent accumulation of organic material in the joints of the pediment top.

There is ongoing delamination of the faces of the arch stones. On removal of loose flakes, salt probably gypsum/calcium sulphate crystals are clearly visible behind.

Salts may be migrating from the top of the pediment, and also from the retained soil around and behind the arch into the stonework. However, the likely cause of gypsum-induced decay is simply that the fabric of the arch is too wet. The pediment roof has been letting in water over a long period and opc mortars have prevented its ready egress through the joints, leading to a concentration of moisture in the stones of the arch themselves. The use of cement-based mortar introduces damaging salts into the masonry substrate in and of itself. Ordinary Portland Cement is 30% sulphate.
The intended breatheability of the arch has been compromised over the years by the use of opc mortars. There are two periods of cement–based repointing. The most recent is of a relatively soft opc mortar, much of it laid over otherwise sound lime mortar. It is easily removed. There is some earlier repointing, however, which is very hard and based upon white cement. White cement sets harder than grey. This mortar has been pressed deeply into the joints. Around these joints there has been a build up of leached out material, possibly previously uncarbonated lime which has set in solution with other compounds from the white cement. It is hard and unsightly. Its removal is necessary, but it has damaged adjoining arrisses.

The construction of the arch is of a high quality, although the vanity of either the architect, the masons or both meant that it was built throughout with very tight joints. In its specific location, the practical consequence of this has been to limit the sacrificial function of the lime mortar joints, significantly reducing the surface area of lime joints for the purposes of rapid evaporation of moisture. The pore structure of this particular limestone is relatively dense, making it less able to accommodate the freezing of water or the crystallisation of salts within that pore structure without damage. The soft evaporation surface has been even more reduced by the addition of opc mortar repointing, so that
excessive evaporation has taken place from the stone itself, leading to a progressive spalling of over-moist stone faces. Many of the stones have a concave profile as a result, the stone adjacent to the joints having fared rather better.

*Removal of cement pointing shows fineness of joints*
A case may be made for the gentle removal of sulphate skins. This would involve the use of micro-abrasive under low pressure in the hands of an experienced stone conservator. Prior poulticing of the sulphate skins with saturated paper pulp would facilitate easy removal. Sand-blasting is NOT an option. Such a procedure is not part of the scope of these works, although the loose edges of blistering will be defrased. Sulphation of limestone locally will be an ongoing problem so long as HGV-use of these roads is high.

All cement mortars were removed, all loose flakes of stone also. Four number losse stones to the pediment cap were loose. These were removed and rebedded. The two stones to the front were originally part of one stone that has been broken into three pieces in the past.

The joints were repointed using a lime mortar; the joints were thoroughly cleared of organic matter and repointed with lime mortar. All water traps were filled with lime mortar, including the tops of projecting key-stones, to provide weatherings. Large areas of delamination to the pediment top were built up with a stone-dust rich lime mortar, to compliment the colour of the original stone. The arch was gently cleaned down using soft brushes and water before, during and after the repointing process. The repair--as opposed to the repointing-mix on the pediment was 1hl2: 1 limestone dust (5mm to dust): 1 sharp sand: 1 plastering sand. The mortar repairs to the pediment top consisted of : 5 hl2: 6 limestone dust: 3 sharp sand: 3 plastering sand. The finer joints of the main structure were pointed with 1hl2: 1 limestone dust: 2 plastering sand. The performance of these mortars over the winter will be assessed in the
spring for vulnerability to frost damage.

The overall character of this arch is one of relatively graceful decay under the influence of moisture, frost, salt attack, and wind erosion. No attempt should be made to restore this arch; presumption should be made in favour of preserving its present character and of managed decay.
LIME MORTAR

The chemical components of an ordinary portland cement and a natural hydraulic lime may often be common. What becomes active in OPC cement, remains inert in an NHL. This can lead to confusion and uncertainty in some laboratory testing methods.

OPC mortars, such as a 1:1:6 cement: lime: sand mix introduce potentially damaging sulphates into masonry walls—in the presence of moisture these will be mobilised and their crystallisation may lead to the accelerated erosion of arrisses and even the faces of softer, but also of harder stones. The addition of even small quantities of OPC (or white cement) will prevent any carbonation of free lime in the mortar. This means that the lime content is a plasticiser and an aggregate only. It delivers no additional flexibility to the finished mortar.

A lime mortar introduces no salts.

A cement mortar, because of its flash set, is riddled with microscopic (and often quite visible) shrinkage cracks from day one—capillary action will pull moisture deep into the structure; water will be trapped and leave the fabric more vulnerable to frost action.

Water accumulates and moves unpredictably through masonry structures.

Lime mortars do not rely upon the resistance of water for their success—They accommodate the ingress of moisture, and then allow its rapid evaporation via the mortar joints, not the face of the stone or brick as occurs when these are pointed with a hard cement mortar. Lime does not allow moisture to linger in the fabric and minimises the potential for frost and soluble salt damage. It is eminently vapour permeable; it offers maximum breatheability.

Lime renders act as a sponge on the face of a building, soaking up water during rainfall, allowing its steady evaporation once the rain has ceased. It is a sacrificial application, that will degrade slowly over time, to be
repaired and replaced. Its application is relatively inexpensive in materials and labour.

Lime mortars are flexible, allowing often quite major settlement to occur in solid wall constructions without compromising their structural integrity. Minor movement will lead to cracking in rigid cement mortars, and to the build up of stresses that lead ultimately to spalling and cracking of stones as well as of mortar. Hairline fractures in lime mortars are ‘self–healing’ being filled over time by leeched calcium carbonate in solution from the mortar.

The character of a traditional masonry structure is given as much by its lime mortar as by its stone. There is a unity between the mortar and the stone; its form of construction was moulded by the combination.

Any serious attempt to recapture the essential character of a structure–its essence– will involve the use of similar, traditional materials laid up with empathy for and understanding of the methods and procedures imposed upon the mason by these materials and their combination. The use of more modern materials will compromise not only the ability of a traditional building to function as its builders intended, but will radically compromise its aesthetic appearance.

Sand used for lime mortar should be well–graded, having a good range of particle size; coarse/sharp or well–graded plastering sand is appropriate, according to the fineness of the masonry; the addition of well–graded crushed stone is appropriate; the use of Portland cement in any proportion is wrong–headed and inappropriate as well as unnecessary in any situation.

St. Astier Natural Hydraulic Lime is readily available; hl2 hydraulic lime from Somerset, England also. Both are reliable products that deliver good performance and all the advantages of a lime mortar. They come in the form of a bagged hydrate, and may be mixed in the same way as a cement. It is greater by volume than cement; 25kg will go up to 3 times as far.

St Astier NHL 3.5 or 5.0 lime should not be used on soft of decayed lime or sandstones. Being well–enough suited to use with granite or other igneous stones, or for new–build with harder limestones and sandstones,
it delivers too hard a mortar in my opinion for use with softer stones. Putty lime, St Astier 2.0 or HL2 hydraulic lime from the UK, with hybrid mixes of NHL and putty lime not ruled out, are more appropriate for use with historic lime and sandstone masonry, delivering less compressive strength and greater vapour permeability.

The use of bagged, hydrated lime available from most builders merchants should not be automatically ruled out where cost-pressure would otherwise lead to the use of ordinary Portland cement. Whilst historic non-hydraulic lime mortars were made with limestone burned at relatively low temperatures, leaving many impurities available for later chemical reaction, this is not the case in the production of the majority of quicklime used to produce lime putty today. Modern quicklime is produced at very high temperature, producing a very pure product. This means that there is very little chemical difference between bagged and putty lime. The main difference is in the maturation time of the rehydrated lime. The greater maturity of putty lime delivers a greater plasticity in use and arguably a more reliable product. The plasticity of bagged lime may be increased by slaking it in water before incorporating it into a mortar. Research by Norman Weiss at Columbia University’s Department of Historic Preservation suggests that the optimum period for this is 48 hours, no increase in plasticity being derived thereafter.

If bagged lime is used, it should be used in conjunction with a pozzalan to assist the set. This could be Metastar (calcined china clay); appropriate brick dust or trass. Bagged lime may also be gauged with a natural hydraulic lime, both to assist speed of set and to strengthen the mortar.

PhD research into the performance of a range of limes and limes in combination for use in pointing and mortar repair is currently being carried out at Bath University by Mike Lawrence, owner of the Ham Hill Stone company.
The successful use of lime requires careful preparation of substrates/stones; sensitive application and conscientious aftercare, yet there is no mystery to this.

BEDDING

Stones or bricks should be well-wetted (preferably submerged in drinkable water and only removed shortly before use) before being built into the wall. The mortar should be quite stiff, not at all sloppy; quite unlike a standard, modern brick-laying mix. The joints may be struck simultaneously with the stone-setting, but the aftercare will be the same. The aggregate must be ‘brought-up’ to enhance the evaporation surface, as well as the appearance of the masonry. This is best achieved by beating the mortar with the bristles of a churn brush, using short, sharp blows. This simultaneously consolidates the mortar. Other methods, such as ragging and brushing risk pulling the mortar away from the substrate.

When repointing brickwork, it is essential that the substrate be well-wetted. However, it is very important that the brick is allowed to dry some before any mortar is introduced. The mortar should be as dry as is manageable/workable, to minimise any running of wet mortar or lime-rich water from the mortar, onto the face of the brickwork. It is very easy to stain brickwork during repointing work, and difficult to remove this staining once the lime has carbonated.

POINTING

Joints should be raked back at least two times their width, leaving any shims of stone introduced into wider joints by the original builders in place if at all possible (setting them aside for reuse, if they come loose).

The use of angle-grinders during the mortar removal process should not be allowed. Mechanical blades are too fast, too aggressive to enable the considered removal of defective mortars. Shims of stone within joints will be destroyed, and thus will the character of the masonry, as well as
historic fabric be compromised. In even the most skilled hands, angle grinders will cut into the brick or stone of the building, leaving unsightly scars. The sharpness of the arriss that may be created in otherwise rough stone ashlar can change the overall character of a masonry elevation significantly.

All dust and debris should be flushed out of the joints with water and areas to be repointed should be saturated twenty-four hours before being worked upon using hoses.

The process should be repeated immediately prior to the start of repointing work and the hose played regularly upon lower areas as yet unpointed even whilst repointing is being carried out above.

The necessity for copious pre-wetting cannot be underestimated.

The drying action of the older mortar inside the wall, as well as of the porous brick or stone would otherwise compromise the adhesion of the new mortar.

Consideration must be given, however, to the possibility or likelihood of water penetrating to the interior of the building, causing previously sound iron fixings to corrode, the mobilization of soluble salts to the detriment of interior finishes, or other associated damage.

The new mortar should be mixed thoroughly prior to use.

Natural Hydraulic Lime–based mortar and hydrated masons lime will work better if re-worked in the mixer 24 hours after first being mixed, although no further water should be added at this stage. This is not essential, and requires experienced judgement. When using the mortar directly after mixing it, workability of the mortar is enhanced by initially mixing the lime only with the water, the aggregate being then added to the lime slurry until the mortar becomes sufficiently stiff.

Putty lime mortar will be easily worked and as plastic immediately after first mixing.

Joints should be wetted again before pointing, but should not be glistening wet when pointing begins.

The mortar should be sticky and stiff, not over-wet or sloppy.
It should be forced into the joint with a pointing iron narrower than the joint width, or fed into the joint with an iron from a trowel or hawk with a minimum of affectation.

It should be compressed but not over-worked, as this would bring too much lime to the front, leaving the main body of the mortar lime-lean and weak. The joint should be left over-full and ‘untidy’ at this stage.

The newly pointed areas should be hung with doubled burlap, which should be damp and which may be regularly dampened thereafter, although not so much at this stage that the mortar behind begins to dissolve and run down the face of the masonry.

The mortar derives its strength from having within it a good range of aggregates and from the steady progress of the hydraulic set and the subsequent carbonation of free lime in the presence of moisture. The walls should be kept covered and moist for at least a week, preferably two, and protected from sun, wind and driving rain as well as from frost.

It is quite possible to work with, particularly hydraulic, lime mortars during the winter months. However, careful attention must be paid to prevailing and predicted weather patterns, and appropriate action taken to minimise the risk of losing mortar to frost. All chemical activity in a lime mortar ceases below 5 degrees Centigrade, and work should not be carried out if temperatures are likely to drop below 10 degrees C for any length of time. Prolonged cold and wet weather will seriously compromise the setting of putty lime mortars and leave them highly vulnerable to frost action. As a general rule, these should not be used December to April. Any work with lime mortar carried out in winter should be covered with hessian for as long as possible after completion of the work.

Surplus mortar may be raked off with a piece of wood after a few hours, or after 24 hours, depending on the weather conditions and the predicted setting time of the lime used, when to do so will not cause any smearing of the mortar onto the face of the masonry.

The mortar should be ‘beaten back’ with a stiff brush around 12–36 hours after being applied, at a point when it has attained a stiffness that does not allow ‘pin-holes’ to be made by striking bristles or lime to be lifted by the bristles and redistributed onto the stones around.

It should not be so stiff as not to allow the removal of lime bloom and the aggregate to ‘come up’ on the beating of the mortar. Leaving a mortar ‘off the trowel’ leaves a lime rich and therefore harder and less
permeable layer which will reduce the breatheability of the mortar and lead, over time, to the decay of the mortar immediately behind the face.

The mortar should then be re-covered. The regular, but considered watering of the wall hereafter will promote the entrainment of carbon dioxide deeper within the structure of the mortar and help to maintain and to prolong a steady carbonation of the lime.

*It is important to stress that a failure to follow this basic procedure will lead to an immediate or premature failure of the mortar.*

A properly designed lime mortar, correctly applied, will perform its intended function for many years and may be expected to last for more than a century. This is something that may not be said of an ordinary Portland cement-based mortar, which will rarely last more than 20 years in the context of a traditional building and which is very damaging to the fabric in the meantime. Any contractor using lime that does not pre-wet the masonry, and does not protect the mortar from too rapid drying is not competent to be carrying out the work.

When the mortar has gained its fuller initial set, after 2 or 3 weeks, then the wall as a whole should be brushed down with a stiff brush and any lime staining teased from the stone with fine stainless steel brushes as necessary.

**VOID TESTS**

Void tests establish the amount of lime required to coat each grain of aggregate in a particular sand. They are performed by adding water to a measured quantity of dry sand until the sample is covered with water. The amount of water added is then calculated and an optimum sand to lime proportion derived.
Useful websites:

www.spab.org.uk

www.buildingconservation.co.uk
site of the Building Conservation Directory, details of specialist contractors, articles.

www.historic-scotland.gov.uk

www.limesolve.demon.co.uk
website of hl2, Hydraulic Lias Limes Ltd, UK.

www.nigelcopsey.com

www.donhead.com

Useful Publications:

Survey and Repair of Traditional Buildings, a Sustainable Approach, Richard Oxley, Donhead;

Historic Scotland Technical Advice Note 1 : Preparation and Use of Lime Mortars;

The Repair of Historic Buildings in Scotland,

Technical Advice Note 10, External Lime Coatings on Traditional Buildings, Historic Scotland.

Available from: Historic Scotland, Scottish Conservation Bureau, Longmore House, Salisbury Place, Edinburgh, EH9 1SH, Tel.: 011 44 131 668 8668.

Repair of Ancient Buildings, AR Powys (available from SPAB, 37 Spital Square, London, E1 6DY, Tel.: 44 208 247 5996)

Structural Repair of Traditional Buildings, Patrick Robson, available from Donhead Publishing Ltd, Lower Coombe, Donhead St Mary, Shaftesbury,
Dorset, SP7 9LY.

Cleaning Historic Buildings (2 volumes), Nicola Ashurst, Donhead Press, Shaftesbury, Dorset;

Conservation of Building and Decorative Stone, Ashurst and Dimes, Butterworth Heinemann;

Society for the Protection of Ancient Buildings Technical Pamphlets:

www.spab.org.uk

The Need for Old Buildings to Breathe, Philip Hughes;

Pointing Stone and Brick, Gilbert Williams;

Treatment of Damp in Old Buildings, Andrew Thomas;

An Introduction to Building Limes, Michael Wingate;

Basic Limewash, Jane Schofield.

SUPPLIERS:

HI2 lime:

Hydraulic Lias Limes Ltd, Tout Quarry, Charlton Adam, Somerset, TA11 7AN, United Kingdom. Available from Walkers builders merchants, Foss Islands Road, York.

Putty lime; limestone dust; premixed plasters: Ryedale Conservation, Terrington, North Yorkshire.

St Astier Natural Hydraulic Limes available from Womersley Associates, Heckmondwike, West Yorkshire. St Astier 5.0 is available from Walkers, York.
Stone dust: 5mm to dust from Wath quarry, Hovingham, North Yorkshire, owned by Lafarge Aggregates.

SUGGESTED LIME MORTAR DESIGNS FOR USE IN THE MALTON AREA:

These mortar designs have been arrived at after assessment of historic mortars found in Malton. They provide a basis only. There is no objective reason to slavishly reproduce a mortar to an historic design that may have failed. However, attention should be paid to historic mortars as found on a project by project basis.

For bedding and repointing of rubble walls and decayed, eroded stonework:

1 part hl2; 1 part limestone dust; 2 parts sharp sand;

OR 1 part putty lime (+10% by volume of lime, Metastar calcined China clay; aggregates as above;

For finer ashlar:

1 part hl2; 1 part limestone dust; 2 parts plastering sand;

OR substitute 1 part putty lime + 10% metastar;

For brickwork:

1 part hl2; 1 part limestone dust; 1 part plastering sand; 1 part sharp sand;

Or: 1 part hl2; 1 part limestone dust; 2 parts sharp sand;
Or: 1 part hl2; 1 part sieved limestone dust; 2 parts plastering Sand.

Or: substitute putty lime (+metastar) for hl2.

The choice of mortar for brickwork will depend upon the type of bricks used, whether 2" C17 bricks or clamp bricks, wire cut or machine-made Victorian bricks. The type of brick used determines the optimum the thickness of the joint.

Mortar repair and mixes will incorporate stone dusts to a possibly higher proportion in pursuit of a colour compatible with the stone substrate. I am in the process of trialing some mixes using Ancaster, bath stone and ham stone dusts, as well as sandstone dusts used locally in the manufacture of pre-cast stone. Crushed sandstone from the Blue Bank Quarry in Sleights may offer similar possibilities.

Long-term, there would clearly be great advantage in the location, identification and re-opening where possible of former quarries locally. Such proposals tend to fall foul of local and sometimes statutory opposition, and the suggestion by Jefferson Consulting that any re-use of old quarries should be for the specific purpose of repair and conservation works (and possibly for limited new use in the context of brownfield enabling developments where appropriate) and should use low-impact methods of extraction to minimise environmental impact is sound.

There are a number of abandoned quarries in the Malton area. The ones closest to the town have been adopted for other uses. There is a large abandoned quarry on York Road, however, that has found no other use, and which is now woodland and scrub. The quarry is large and probably supplied a large volume of the sandstone used locally. The stone was transported from the quarry to the River Derwent via a tunnel beneath York Road, which tunnel remains, albeit blocked.

The quarry-faces are up to 12 metres high in places, with bedding planes clearly visible. It would seem that the seams of stone were by no means exhausted when the quarry closed. The trees growing on the quarry floor are of a good age, 100 years at least, being many of them Beech.

This quarry would seem to be the most likely viable source of like stone for use in conservation and repair (and possibly new build) works in Malton.
York Road sandstone quarry.