An assessment of the aggregate properties of the Lower Lincolnshire Limestone in south Lincolnshire and surrounding areas

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An assessment of the aggregate properties of the Lower Lincolnshire Limestone in south Lincolnshire and surrounding areas

T. P. Bide, A. J. M. Barron and D. J. Evans

Contributor/editor
D.G. Cameron and J.M. Mankelow

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British Geological Survey offices

BGS Central Enquiries Desk
Tel 0115 936 3143 Fax 0115 936 3276
email enquiries@bgs.ac.uk

Environmental Science Centre, Keyworth, Nottingham NG12 5GG
Tel 0115 936 3241 Fax 0115 936 3488
email sales@bgs.ac.uk

Murchison House, West Mains Road, Edinburgh EH9 3LA
Tel 0131 667 1000 Fax 0131 668 2683
email scotsales@bgs.ac.uk

Natural History Museum, Cromwell Road, London SW7 5BD
Tel 020 7589 4090 Fax 020 7584 8270
Tel 020 7942 5344/45 email bgslondon@bgs.ac.uk

Columbus House, Greenmeadow Springs, Tongwynlais, Cardiff CF15 7NE
Tel 029 2052 1962 Fax 029 2052 1963

Maclean Building, Crowmarsh Gifford, Wallingford OX10 8BB
Tel 01491 838800 Fax 01491 692345

Geological Survey of Northern Ireland, Department of Enterprise, Trade & Investment, Dundonald House, Upper Newtownards Road, Ballymiscaw, Belfast, BT4 3SB
Tel 028 9038 8462 Fax 028 9038 8461
www.bgs.ac.uk/gsni/

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU
Tel 01793 411500 Fax 01793 411501
www.nerc.ac.uk

Website www.bgs.ac.uk
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Summary

This report was commissioned by Lincolnshire County Council to compare the aggregate properties of limestone produced in quarries in south Lincolnshire and neighbouring areas with aggregates likely to be obtained from limestone at the site of the proposed Gorse Lane quarry. This report has considered evidence from geophysical records, boreholes and geological mapping to assess the properties for aggregates and heterogeneity of the Lincolnshire Limestone, specifically the Lower Lincolnshire Limestone Member which underlies the Gorse Lane site.

Due to the variable nature of the geology, it is possible that limestones from the Gorse Lane site may have better aggregate properties when compared to other sites in the area. However there is no conclusive evidence that this is the case. Within the Lower Lincolnshire Limestone there are distinct units, divided by prominent geological marker horizons, which show regional lateral continuity. This suggests material from the proposed site may have similar properties to nearby quarries, the closest of which have produced frost-susceptible Type 1 sub-base in the past. However, within these units, which are traceable across the area, there is considerable lithological variation. Variation in aggregate properties from site to site is therefore a distinct possibility and the prediction of aggregate properties based on mapped geology is problematic.

The applicant has reported that limestone from Gorse Lane meets the requirements for non-frost susceptible Type 1 sub-base material, which no other quarry within Lincolnshire currently produces. However, several quarries in the region have worked, or currently work, the Lower Lincolnshire Limestone for non-frost-susceptible Type 1 sub-base (Peterborough) and many more for frost-susceptible Type 1 sub-base in Lincolnshire and Northamptonshire. It is possible the current lack of quarries producing non-frost-susceptible Type 1 sub-base in Lincolnshire may be due to the economics of processing this material, when compared to available alternatives, rather than constraints associated with the geology.
1 Introduction

Lincolnshire County Council (LCC) has received a planning application relating to limestone extraction for use as aggregate from an area south of Denton to the south-west of Grantham. The proposed site, referred to as Gorse Lane, lies within an area covered by a dormant planning permission, which the applicant wishes to activate. The bedrock geology underlying the site, and the unit hosting the target mineral, is the Lower Lincolnshire Limestone. Although the Lower Lincolnshire Limestone is worked for crushed rock aggregate elsewhere in the region, it is, with a few exceptions, used mainly for fill and generally requires blending with other products to meet the specifications required for road-building material and other higher end applications with more demanding specifications. No quarries within Lincolnshire produce non-frost-susceptible Type 1 sub-base aggregate. The only two quarries working the Lincolnshire Limestone currently producing material that meets the required specifications for this are in Peterborough. The applicant has reported that the Gorse Lane site can also produce aggregates suitable for non-frost-susceptible Type 1 sub-base aggregate.

This report reviews the potential of the Lower Lincolnshire Limestone for use as aggregate and gives an indication of the variability of the unit’s properties through the outcrop and shallow subsurface across this part of Lincolnshire and parts of the surrounding counties. This will aid in an assessment of the variability of Lower Lincolnshire Limestone between this site and other nearby working limestone quarries that do not produce non-frost-susceptible Type 1 sub-base aggregate but lower specification crushed rock products and building stone.

Figure 1. The outcrop of the Lower Lincolnshire Limestone from south Lincolnshire to Northamptonshire. Contains Ordnance Survey data © Crown Copyright and database right 2015 Geological data © NERC 2015.
2 The Lincolnshire Limestone and its properties for aggregates

The Lincolnshire Limestone Formation is Middle Jurassic in age (174-164 million years) and crops out extensively throughout Lincolnshire, running north – south through Grantham and Lincoln and continuing west into Leicestershire and south into Northamptonshire. The outcrop of the Lower Lincolnshire Limestone, the geological unit of interest at the proposed site, is shown in Figure 1.

Regionally (south Lincolnshire) the Lincolnshire Limestone Formation is typically between 25 and 33 m thick and is formally divided into the Upper and Lower Lincolnshire Limestone Members, which are widely shown on BGS maps. Over the years however, through studies of quarries, the Formation has been further subdivided by various authors, principally Ashton (1980), into schemes with many named units, some of them as lithostratigraphical Members, others of which are local building stone names. A number of the lithostratigraphical terms have been used in certain recent accounts (Cox and Sumbler, 2002), and although BGS regards them as not mappable across country, and having local applicability at best (Barron et al., 2012), we have found some of them to be of some utility for current purposes (see 3 below). Figure 2 shows the main subdivisions of the Lincolnshire Limestone in the adjoining Grantham district, and illustrates the lateral variability of the succession of limestone types, here over a distance of about 16 km.

The Lower Lincolnshire Limestone Member’s main rock types are lime-mudstones/calcilutite, and peloidal packstones and wackestones (i.e. limestones with lime mud matrices). The Upper Lincolnshire Limestone Member is dominated by typically medium to very coarse-grained, commonly cross-bedded, ooidal limestones and bioclastic limestones (which comprise shell fragments and other skeletal remains), all generally with a grainstone texture (i.e. cemented by calcite spar). Both units commonly contain subordinate silty, sandy or muddy beds of terrigenous origin (silicate grains) (Berridge, 1999). Due to the differences between the two Members and the absence of the Upper Lincolnshire Limestone at Gorse Lane, it is not relevant to compare the proposed site with sites quarrying only the Upper Lincolnshire Limestone.

The entirety of the Lincolnshire Limestone Formation has undergone some degree of post depositional alteration (diagenesis) as fluid flowed through the rocks, causing recrystallisation and alteration. This adds further complications to categorising the unit in terms of aggregate resources as these secondary processes can significantly change the rock’s physical properties.

There is little available information on this alteration and it may be localised and unpredictable in lateral and vertical extent, and in nature and intensity.
Figure 2. A comparison of sections from quarries from across the Lincolnshire Limestone of the Grantham district showing the lateral lithological variability (after Berridge, 1999, fig. 21).
2.1 GEOPHYSICAL INVESTIGATIONS INTO THE PROPERTIES OF THE LINCOLNSHIRE LIMESTONE

Although boreholes in this area lack lithological descriptions, they are associated with geophysical investigations from which inferences can be made regarding the lateral continuity of units within the Lincolnshire Limestone Formation. Downhole geophysical logs (mainly gamma-ray) are available for a number of coal exploration boreholes within five kilometres of the Gorse Lane site, including Croxton Abbey, Swallow Hole, Egypt Plantation, Three Queens, Great Osgrove Wood and Five Oaks Cottages (Appendix 1). These were drilled in the mid-1970s, by BPB Drilling, during exploration for the Vale of Belvoir prospect. Downhole geophysical logs were acquired across the Lincolnshire Limestone interval, which are shown in Appendices 1 and 2 along with number of other boreholes from elsewhere in southern Lincolnshire. Many of the gamma-ray log peaks/characteristics correspond to the major lithostratigraphic boundaries of Ashton (1980, see Figure 3).

However, as a result of the shallowness of the Lincolnshire Limestone around the proposed site (i.e. at or near crop), log quality is generally poor, due probably to weathered strata and poor hole conditions. As such, it is difficult to identify and be certain of log characteristics that can readily be recognised and traced from one borehole to the next.

The Lincolnshire Limestone is an important aquifer and a previous study by Emery & Dickson (1991) presented a series of gamma ray logs and correlations in two N-S (30 km) strike sections in an area to the north of Grantham, central Lincolnshire (Appendix 2). They demonstrated that the Lincolnshire Limestone shows a clear vertical change of lithofacies, but a lack of major lateral lithofacies change. They illustrate that, although the Lincolnshire Limestone Formation has a complex facies association, it can be correlated throughout central Lincolnshire from outcrop, core and log data and support the lithostratigraphic scheme proposed by Ashton (1980). Sequences can be traced up to 30 km down-dip (east) from the outcrop, which Emery & Dickson (1991) suggest shows that the regional slope on which these sediments were deposited must have been extremely gentle and that facies belts were wide and stable.

For the immediate area of study (Appendix 1), coal exploration boreholes in the main provide geophysical logs across sequences of the Lower Lincolnshire Limestone (Sproxton and Greetwell members), with those further to the east (Great Osgrove Wood and Five Oaks Cottages) imaging the upper levels of the Formation and consequently providing better logging of the lower sequences of the Lincolnshire Limestone (Appendix 1). It should be noted however, that there is some question over the depths quoted for stratigraphic levels in the coal exploration borehole logs held and those with the gamma logs used. The borehole log descriptions held by BGS state “BPB gamma log depths increased by [stated amount, e.g. 3.90] to agree with drillers depths for cored part of borehole”. Taking the depths in the descriptions (bracketed numbers alongside stratigraphic picks in Appendix 1), the log character of the Lincolnshire Limestone interval in some coal boreholes does not correspond to the same stratigraphic interval or log character in the cored Bloxholm (GD) borehole used by Emery & Dickson (1991). The gamma-ray log interpretations and correlations shown in Appendix 1 take the BPB log depths measured from drilling datum of rotary table (R.T.) and correct these for the ground level heights (G.L.), which are close to the correlation of the log response in the Lower Lincolnshire Limestone in the Bloxholm borehole.

In the Croxton Abbey and Egypt Plantation boreholes, the lower levels of the Lincolnshire Limestone appear characterised by quite strong log responses, with two marked troughs and peaks, the lowest peak being sharp, the upper more rounded. Comparing these signatures to those of the boreholes to the north in Emery & Dickson (1991), the lower peak is similar to that seen just above the base of the Lincolnshire Limestone in, e.g., the Aunsby, Bicker and Donington boreholes (Appendix 2).
Despite these correlations, there remain uncertainties over some log descriptions’ depths and the quality of the geophysical logs in some of the boreholes is poor (notably Swallow Hole, Three Queens and Great Osgrove Wood). As a result, although the geophysical logs suggest units within the Lincolnshire Limestone are laterally continuous, they appear to be of limited assistance in helping to correlate and determine the nature of the Lower Lincolnshire Limestone sequence to the scale required for the determination of aggregate properties in the area of interest at this point in time.

2.2 HETEROGENEITY OF THE LOWER LINCOLNSHIRE LIMESTONE

The Lower Lincolnshire Limestone Member beds were deposited in a complex low-energy, shallow marine carbonate-shelf environment of lagoons and tidal flats, migrating landward (westward). As shown by geophysical logs and Emery and Dickson (1991), the various environments of deposition were laterally continuous and stable. As a result, lateral correlation of units, divided by significant sedimentary breaks and broad similarities of lithological properties, is possible over a wide geographic area. However, within these units, detailed logs show a complex internal stratigraphy and a wide range of carbonate lithologies. Rapid lateral and vertical lithofacies changes are common and are demonstrated by a comparison of lithologies seen in quarry sections shown in Figure 2 and Figure 3 and described by Ashton (1980) and Emery and Dickson (1991).

This heterogeneity is also confirmed by hydrogeological investigations into the properties of the formation as an aquifer. A BGS study concluded that porosity and permeability (key factors in water absorption, one of the main limiting factors for the Lincolnshire Limestone as an aggregate) varied greatly and no, or at best, a weak relationship could be established between permeability and lithology (Bird, 1974). This lack of relationship may indicate that the physical properties of the formation could also be affected by diagenetic processes on a locally variable level.

Ashton (1980) gives a comprehensive account of the Lower Lincolnshire Limestone Member and compares sections from many cuttings and disused quarries across Lincolnshire and Leicestershire. A comparison of sections figured by Ashton (1980), for the Little Ponton, Waltham on the Wolds and Sproxton quarries (see Figure 3) and in the Grantham district (summarised in Figure 2), shows that in the district around the proposed quarry the Member comprises a sequence of peloidal and ooidal limestones separated by a few thin clay/mudstone beds. Although marker beds such as hardgrounds (breaks in limestone deposition) and erosive surfaces can be traced between some (but not all) sections, aside from the basal 1-2 m of laterally persistent sandy and silty limestones in the south-west, the lithologies can only be very broadly correlated as many lithofacies appear to be constrained locally (beds pinch out) and change abruptly. This correlation around the proposed site is discussed in section 3 below.

This comparison of lithologies along the outcrop also shows that the lithological succession is very different for the quarries currently working the Member around Lincoln (Harmston Heath and Dunston) when compared to the more southerly ones (South Witham) as demonstrated in detailed logs from these sites in Ashton, 1980. The Lower Lincolnshire Limestone worked in the north has higher numbers of clay partings, sandy layers and is micritic (limestone made up of microcrystalline, i.e. very fine grained, calcite), rather than ooidal limestone. Unfortunately there are no detailed sections for the Lower Lincolnshire Limestone in Peterborough around the Thornaugh, Collyweston and Cross Leys Quarries. Boreholes in this area are generally for ironstone exploration and give little information on the detailed lithology of these rocks, only showing that thicknesses are consistent with those seen further north.
Figure 3. Correlated sections of Sproxton and Little Ponton quarries (after Ashton, 1980, fig. 6).
2.3 **AGGREGATE PROPERTIES**

The Lincolnshire Limestone Formation is the most significant limestone unit in the region and has long been an important source of building stone with eight quarries currently working the Formation solely for that purpose. The unit is also a resource for crushed rock aggregate, currently nine quarries within Lincolnshire and ten in Rutland, Peterborough and Northamptonshire are working on the outcrop (Figure 4, Table 1). Quarried limestone, however, is often blended with recycled and other materials at source to improve product specifications. Nine of these quarries work the Upper Lincolnshire Limestone and the remaining ten, the Lower Lincolnshire Limestone (Cameron et al., 2014).

It is difficult to characterise the main lithologies of the Upper and Lower Lincolnshire Limestone Members in terms of properties for crushed rock aggregate use, as there are several factors involved and that control the physical properties of the rock. These include the presence of mud layers and any post-depositional (diagenetic) processes such as dolomitisation and dissolution of calcium carbonate. However, limestones with existing high porosities, such as grainstones and packstones, are more susceptible to dissolution which will lead to higher water absorption characteristics.

Generally, aggregates produced from the Lincolnshire Limestone are of relatively low strength (typically measured by the Los Angeles Abrasion Test) and have poor resistance to frost damage, due to moderate to high levels of water absorption (Berridge, 1999; Harrison et al., 2003). As a result, the formation is not particularly suitable for use in concrete or as a Type 1 sub-base in road construction and the primary end use is bulk fill. Quarries which have worked the Lincolnshire Limestone for Type 1 sub-base material have done so by the process of re-crushing oversize material from the primary crushing process; this removes weaker rock fragments and reduces the fines content of the final product (a process described to the authors by Lincs Laboratory and members of the aggregate industry). As a result of the Lincolnshire Limestone not being widely considered as an aggregate resource, little research and testing for such use has been undertaken, hence there is a lack of available data on the aggregate properties. Research undertaken by the Building Research Institute into the suitability of Jurassic limestones for concreting applications, focussed on limestones from Southern England with only two samples from the Upper Lincolnshire Limestone (Collins, 1983). Test results for water absorption density and strength from samples of the Lincolnshire Limestone gave similar values to samples from other Jurassic limestones. The study concluded that the mineralogy and composition of the matrix of the rock had a great effect on water absorption, a property determined by both the depositional environment and subsequent rock-forming processes, both of which changed significantly throughout the succession. As a result, it is difficult to spatially determine aggregate properties. Overall the study found that concrete made from Jurassic limestones was susceptible to freeze-thaw due to high water absorption and also that excess fines were produced during processing, issues not dissimilar to those preventing the rock being utilised for road stone.
Figure 4. Active quarries in the Lincolnshire Limestone (data from Cameron et al., 2014). Contains Ordnance Survey data © Crown Copyright and database right 2015. Geological data © NERC 2015.
Data from the Lincs Laboratory, who test aggregate materials for use in highway and construction projects, show that in the last 20 years, nine quarries have produced frost-susceptible Type 1 sub-base material from the Lincolnshire Limestone: Harmston Heath, Great Ponton; Brauncewell; Collyweston; Stainby; Longwood; South Witham; Leadenham and Cross Leys Quarries. Of these, four are located in the Lower Lincolnshire Limestone and are within 20 km of the proposed quarry at Gorse Lane. Only two of these (Cross Leys and Harmston Heath) are currently on the Lincolnshire County Council approved suppliers list for frost-susceptible Type 1 sub-base (Lincs Laboratory, 2015). For non-frost-susceptible Type 1 sub-base, which is what the Gores Lane site is reported to be able to produce, there are only two sites on the Lincs Laboratory approved supplier list, Thornhaugh Quarries I and II. These are both in Peterborough around 20km south east of the Gores Lane site (Lincs Laboratory, 2015). These quarries show it is possible to produce non-frost-susceptible Type 1 sub-base form the Lower Lincolnshire Limestone, although it is rare for quarries to do so.

One possible explanation for the low number of quarries exploiting the Lincolnshire Limestone for sub-base may be the ready availability of secondary aggregates from the recycling of construction and demolition waste in the area. The properties for aggregate use of these materials are more predictable than the locally variable Lincolnshire Limestone, leading to a lower risk of the presence of deleterious material causing excessive fines or weak aggregates.

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Table 1. Quarries working the Lincolnshire Limestone, or that have previously been worked for sub-base aggregate.
3 The Lincolnshire Limestone around the proposed site

The proposed application area lies almost entirely within the outcrop of the Lower Lincolnshire Limestone Member, with part of the northern edge of the site including outcrops of the underlying Grantham and Northampton Sand formations, which comprise ironstones, siltstones and sandstones (Figure 5). Some minor faulting is also mapped across the site, but no superficial deposits are recorded.

Locally, boreholes held in the BGS archives were made for hydrological purposes or ironstone or coal exploration. Therefore, although the borehole coverage is very good (Figure 5), detailed lithological descriptions of rocks near the surface, including, critically, the Lower Lincolnshire Limestone Member, are generally absent from the logs. This precludes any correlation of geological units within the Member (e.g. individual beds) and assessment of their geological continuity across the site from these data. The borehole logs do show, however, that the Member is around 5 to 10 m thick with a maximum thickness of 14 m in the south-west of the site, thinning to 2 to 5 m along the north edge and feathering to zero at the edge of the outcrop. The thicknesses across the central part of the site are a fairly constant 8 to 10 m. This range of thicknesses seen over the site is consistent along the outcrop to the south and north, with a maximum recorded of around 10 m.

Two nearby sections in the Lower Lincolnshire Limestone were logged in detail by Ashton (1980), at Sproxton Quarry and Little Ponton Quarry (Figure 3), approximately 5 km respectively south-west and north-east of the Gorse Lane site along the Member’s outcrop. The Little Ponton section records 12 m of beds from the middle and upper part of the Member, however, the Sproxton Quarry section displays 17 m of the Member, including the base, and is reproduced and re-described by Cox and Sumbler (2002, pp 286-289). The logs from these two sites show that the lithologies are broadly similar, and that the correlation of the divisions proposed by Ashton (1980) between them seems valid (Lincoln Member on Greetwell Member, Figure 3), with the boundary placed at a significant sedimentary break. Thus it is reasonable to infer the presence of these units in the intervening ground, including the proposed quarry. However, examining the logs in detail, on a scale of a few metres, there is significant variation between them, with both sections displaying a different succession of limestone lithofacies. For instance, the interbedded lime-mudstone and silicate mudstone unit of Ashton’s Ropsley Beds (part of the Lincoln Member) seen at Little Ponton is absent at Sproxton, and some conspicuous lime-mudstone beds in the Greetwell Member at Sproxton are not seen at Little Ponton. In addition, the Sproxton section includes many sharp bed boundaries which cannot be correlated at Little Ponton.

Apart from comments about limestone texture (packstone/wackestone/grainstone – see Glossary), the accounts of sections cited above give little, if any, information on the variability of the cementation of the strata or any indications of diagenetic changes. Some work on this aspect of the Lincolnshire Limestone Formation has been done, mainly by Emery (see for example, Emery, 1991 and Emery and Dickson, 1989), but his study areas lie away from the current site, and focus on the Upper Lincolnshire Limestone. Thus we are unable to throw any light on cementation and diagenetic variability in the study area and hence its implications for water absorption characteristics.
Figure 5. The proposed site with locations of boreholes known to BGS and bedrock geology. Contains Ordnance Survey data © Crown Copyright and database right 2015. Geological data © NERC 2015.
4 Conclusions

Unfortunately, little available information exists regarding the aggregate properties of the Lincolnshire Limestone, which broadly reflects the fact that this unit is not widely considered as an aggregate resource and so has not been studied as such. The main limiting factors for the Lincolnshire Limestone constituting a poor aggregate resource, is its strength and water absorption. These are related to both the lithological makeup of the unit as well as diagenetic mineralisation. As several studies have shown, both of these properties are poorly geographically constrained and vary considerably across the outcrop (Bird, 1974; Emery, 1991; Emery and Dickson, 1989, 1991), making comparison of aggregate properties problematical, both between quarries and, on a larger scale, across the proposed Gorse Lane site. Although subdivisions of the Lower Lincolnshire Limestone, such as the Greetwell and Sproxton Members, can be traced laterally over tens of kilometres, there is enough variation within the rocks that make up these units to make classification, with regard to aggregate properties, difficult.

Although no quarries currently work the Lincolnshire Limestone for non-frost-susceptible Type 1 sub-base material within Lincolnshire, and only two sites do across the East Midlands and East of England, it is entirely possible that this specification can be met from the Gorse Lane site. The Lincolnshire Limestone varies considerably across its outcrop and clear differences between the Upper and Lower Lincolnshire Limestones, coupled with differences between the Lower Lincolnshire Limestone in south and north Lincolnshire, mean that quarries that work these units cannot be used in comparative studies with the Gorse Lane site. Also, two neighbouring quarries working the Lower Lincolnshire Limestone in Peterborough do produce materials which meet the specifications reported by the applicant from tests on the Gorse Lane site. This would suggest that, with the correct processing and quarrying techniques applied to remove deleterious elements, it is feasible that the Lower Lincolnshire Limestone in south Lincolnshire (from the proposed Gorse Lane site or elsewhere) may be able to produce non-frost-susceptible sub-base material. Indeed, it may even be possible for existing quarries to produce this material if it was economically feasible to do so. It may be the case that the lack of quarries currently producing this type of material within Lincolnshire may not be an indicator of the physical properties of the rock. Rather, it is possible that this may be a reflection of the economics of processing the material to meet the required specifications compared to the cost of processing recycled aggregates, which require less processing to produce the same quality aggregate.

The bulk properties of the formation, when taken as a whole, appear show some lateral continuity, as depicted in detailed sections and shown by geophysical logs. However, within these laterally continuous units, lithologies can vary and properties can also be greatly affected by post depositional mineralisation. This, coupled with a lack of data on the aggregate properties of these rocks, makes predicting aggregate properties very difficult. Despite the difficulty of predicting the aggregate properties of the Lincolnshire Limestone, there is no publicly-available evidence that limestone at Gorse Lane should produce significantly different aggregates than that produced from the nearest comparable quarry at South Witham. This quarry currently produces low-grade crushed rock aggregate and has produced frost-susceptible Type 1 sub-base in the past. Conclusive evidence can only be gained by testing representative samples from the Gorse Lane site to the relevant BSI specifications and comparison of these test results with other sites within the region.
Glossary

Calcilutite: mud-grade limestone.

Cross bedding: a sedimentary structure with inclined surfaces formed during deposition of migrating bedforms such as ripples and dunes.

Diagenesis: post-depositional physical, chemical and biological processes and changes in sediments as they become rock, and post-lithification changes, but excluding weathering and metamorphism.

Dolomitisation: the process under which calcium carbonate (CaCO$_3$) is changed to Dolomite (CaMg(CaO$_3$)$_2$).

Gamma ray log: A geophysical borehole log which measures natural radiation from adjacent wallrock.

Grainstone: grain-supported rock with little matrix and the pores between grains filled by spar: in limestones, usually carbonate mineral such as calcite or aragonite.

Lithofacies: a subdivision of a stratigraphical unit, distinguished from adjacent units on the basis of its lithology (rock type).

Lithostratigraphical: relating to classification and naming of stratified rocks based on rock type.

Matrix: fine grained material separating clasts in a sedimentary rock.

Ooid: a spherical or sub-spherical grain, up to 2 mm in diameter, formed, usually on the sea floor, by precipitation around a nucleus of a series of concentric layers of minute crystals of (in limestones) calcium carbonate.

Packstone: grain-supported rock with intergranular spaces filled by matrix, such as mud or silt; in limestones, usually a lime mud.

Peloid: rounded or sub-rounded grain composed of structureless microcrystalline carbonate. May be faecal in origin.

Spar: discernible crystals, e.g. forming the cement of a rock.

Type 1 Sub-base: a graded aggregate material produced from crushed stone or recycled material which, when compacted, has excellent load bearing properties.

Wackestone: matrix-supported rock, i.e. grains not generally in contact.
References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: http://geolib.bgs.ac.uk.


COLLINS, R. 1983. Concrete from crushed Jurassic limestone. Quarry Management and Products, Vol. 10


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Appendix 1  Geophysical logs and tentative correlations for the Lincolnshire Limestone

Geophysical logs and tentative correlations for the Lincolnshire Limestone in the area of interest and further afield in southern Lincolnshire. Bloxholm Borehole gamma-ray log from Emery & Dickson (1991). Depths of the gamma logs are from logging datum (RT); depths in brackets alongside stratigraphic picks are those from the borehole logs and relative to ground level (GL).

RT = 153.27 m  
GL = 150.3 m  
= 3 m  
BPH logs inc 3.90m  
Croxton Abbey

RT = 154.9  
GL = 151.5  
= 3.4 m  
BPH logs inc 4.30m  
Swallow Hole

RT = 105.4 m  
GL = 102.6 m  
= 2.8 m  
BPH logs inc 3.6 m  
Egypt Plantation

RT = 101.0 m  
GL = 93.9 m  
= 7.1 m  
Great Osgrove Wood

RT = 105.4 m  
GL = 102.8 m  
= 2.8 m  
Five Oaks Cottages

RT = 105.4 m  
GL = 102.8 m  
= 2.8 m  
BPH logs inc 3.6 m  
Egypt Plantation
Appendix 2  Geophysical log interpretations and correlations of the Lincolnshire Limestone to the NE of Grantham

Adapted from Emery & Dickson, 1991.
(a) gamma-ray log signature correlated with the lithostratigraphy from core in the Bloxholm (GD) borehole, b) location map showing the western (c) and eastern (d) strike line oriented gamma ray log correlations. Gamma ray logs are hung from the top of the Lincolnshire Limestone.