Geology and engineering aspects of the Leadenham By-pass, Lincolnshire

P. Green

Abstract: This article gives an account of a non-geologist's encounter with the geology of the Lincoln Edge, as experienced during construction of a by-pass road for the village of Leadenham, Lincolnshire in 1994-95. The geology and related constraints determined during the ground investigation are described, together with their bearing on the design and construction of the road scheme.

Introduction

The village of Leadenham, Lincolnshire is situated on the A17 Newark to King's Lynn Trunk Road. The road carries a high volume of traffic between the East Midlands and the agricultural production areas of Lincolnshire, the Fens and North Norfolk, together with the East Coast ports of Boston and King's Lynn. Over 50% of the traffic is heavy goods traffic and the need for a by-pass had long been recognised.

Leadenham village lies on the junction of the A607 road with the A17 (Fig. 1). It is situated halfway up the topographical feature known as Lincoln Edge, a prominent escarpment which extends for many kilometres both northwards and southwards from Lincoln. The scarp slope is formed mainly by the mudstones and subordinate limestones and ironstones of the Lias Group, Northampton Sand Formation and Grantham Formation (Table 1). The village occupies a 400m-wide bench about halfway up the scarp slope at an altitude of approximately 50m AOD. The bench is formed by the outcrop of the Marlstone Rock Formation, which is more resistant to erosion than adjacent strata above and below. Siting of the village was no doubt influenced by the fact that the Marlstone Rock Bed is an excellent aquifer. The Marlstone Rock bench effectively divides the scarp slope into lower and upper parts. The underlying Brant Mudstone Formation forms the lower scarp, sloping steeply down to the floodplain of the rivers Brant and Witham. Above the village, the ground steepens to form the upper scarp, carved out of the Whitby Mudstone, Northampton Sand and Grantham formations. The scarp ultimately rises to an altitude of 100m AOD, and is capped by the resistant limestones of the Lincolnshire Limestone Formation, which form a long, gentle dip slope to the east.

The route of the completed by-pass is shown in Figure 1. The new road leaves the former route of the A17 about 1.3km west of Leadenham and curves in a south-easterly direction over the predominantly arable farmland of the Leadenham Low Fields. The route continues across the arable land to the south of Leadenham Park, swinging eastwards and starting to rise on a low 2-3m high embankment towards the toe of the lower scarp. Midway up the lower scarp, the road enters a cutting (the Mill House cutting, Fig. 1) which deepens rapidly to a depth of 8m beneath a new bridge carrying the A607 road over the by-pass. The by-pass continues to rise in a

Age	*Group*	*Formation*	*Former Name*	*Thickness proved on site*
Middle Jurassic	Inferior Oolite Group	Lincolnshire Limestone Formation	Lincolnshire Limestone	lowermost 5m
		Grantham Formation	Lower Estuarine Series	4.6m
		Northampton Sand Formation	Northampton Sand	
Lower Jurassic	Lias Group	Whitby Mudstone Formation	Upper Lias	45m
		Marlstone Rock Formation	Marlstone Rock Bed	2.7-3.3m
		Brant Mudstone Formation	Middle Lias	uppermost 35m

Table 1. Summary of the stratigraphy of rock formations encountered during site investigation and construction of the bypass.

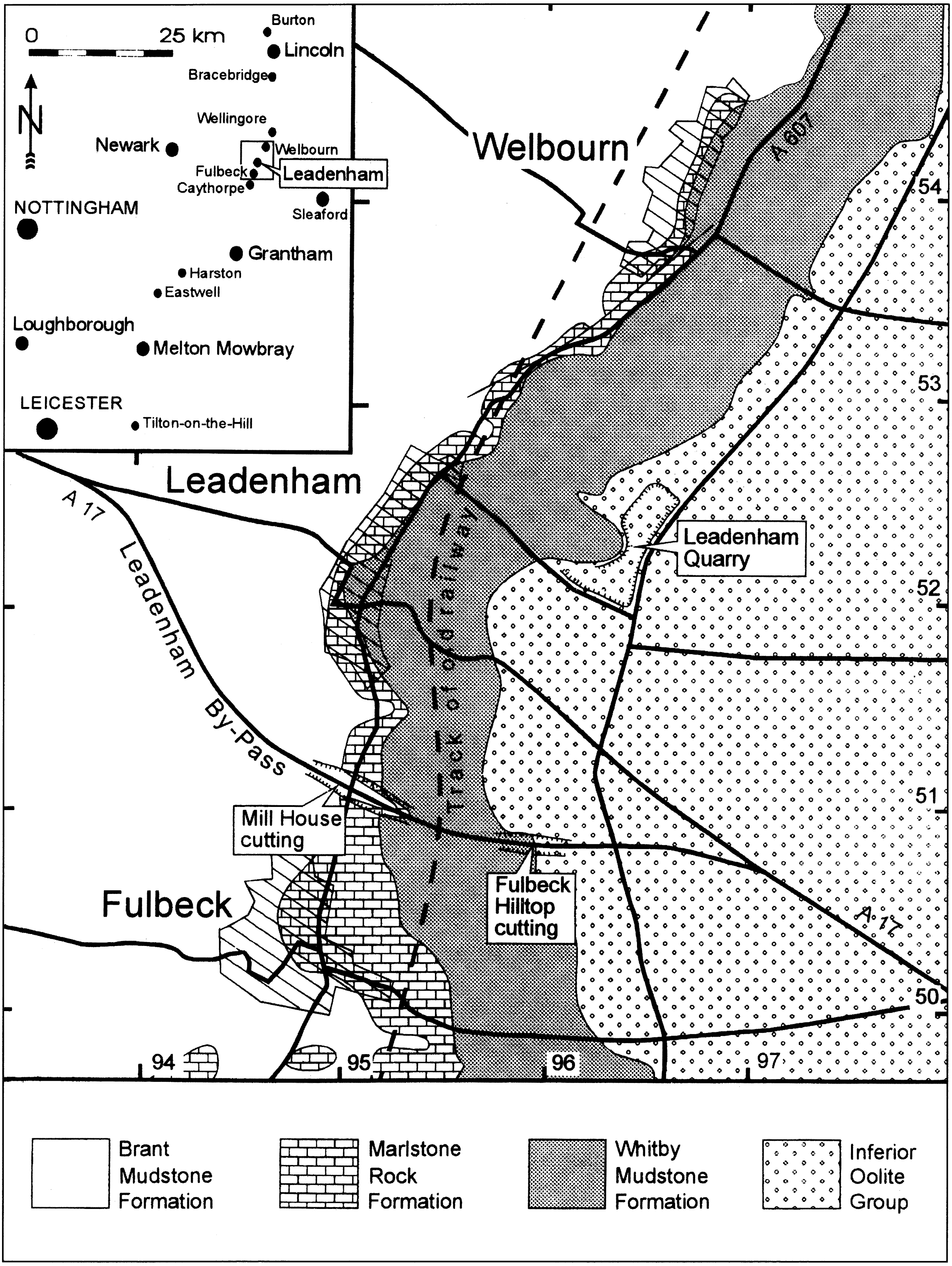

Fig. 1. Map showing route of the by-pass over the geology of the area, based on British Geological Survey 1:10,000 maps (modified after Sumbler and Ivimey-Cook, 1996).

shallow cutting through arable land to cross the disused Lincoln-Grantham railway. It then climbs diagonally across the face of the upper scarp, requiring a cutting of up to 5m depth (the Fulbeck Hilltop cutting, Fig. 1) before reaching the crest, from which the ground slopes gently away to the east at an angle of about 2 degrees.

Ground Investigation

In a roadworks scheme of this type, much ground investigative work must be carried out to determine the properties of the soils and underlying bedrock strata, so that geotechnical design criteria can be identified and recommendations for road construction formulated. The ground investigation for the Leadenham by-pass spanned a number of years. The first detailed investigation was carried out in 1971 (Chandler, 1982), augmented later by others as the preferred route was finalised. Further specialist ground investigation was carried out in 1989 along the anticipated preferred route. Major sources of documentary information used by these investigations included the geological maps, principally the 1:50,000 series Sheet 127 (Grantham) (British Geological Survey, 1972; 1996), together with MAFF soil classification maps. Ordnance Survey topographical maps and aerial photographs.

Site investigations typically involve excavating numerous trial pits to depths of 2-3 metres, supplemented in places by boreholes to depths of up to 20 metres, in order to examine the strata underlying the route and to extract both disturbed and undisturbed samples for laboratory analyses and testing. The diverse range of geotechnical tests carried out are listed in Table 2 and are designed to determine the engineering properties of the rocks and soils that would be encountered during the construction of the scheme.

Undrained Triaxial Compression Strength
One Dimensional Oedometer Consolidation cv
California Bearing Ratio
Compaction
Natural Moisture Content
Bulk Density
Plastic Limit
Liquid Limit
Plasticity Index
Particle Size Distribution
Specific Gravity
Organic matter content
Sulphate content
pH value
Point Load Index
Uniaxial Compression Strength
Consolidated Undrained Triaxial Compression Strength
Pore water pressure measurement and Value change measurement

Table 2. Principal tests to determine the engineering properties of rocks and soils (British Standards Institute 1975; 1981).

The site investigation and testing data was used to:

- determine the suitability of the various soils encountered for use as construction materials;
- determine safe slopes for cuttings and embankments;
- assess possible excavation methods;
- examine and assess foundation conditions at the bridge site;
- assess groundwater conditions and ascertain the drainage required;
- locate potentially unstable areas.

Having obtained a detailed understanding of the materials likely to be encountered, their physical properties, and more importantly how those properties would vary in response to changes in environment, the Consulting Engineer was able to proceed with the detailed design of the road scheme.

Geology

Solid Geology. The Lincolnshire Limestone Formation crops out at the crest of the upper escarpment and forms the dip slope to the east. It consists of buff grey, fine-grained oolitic limestone. Weathering along the bedding planes and joints has left a residue of yellowish sand which fills many of the joints. The Lincolnshire Limestone is underlain by the Grantham Formation (formerly known as the Lower Estuarine Series), which consists of fine sands and clay with low grade iron ore, particularly in the basal sand layer. Underlying the Grantham Formation, the Northampton Sand Formation consists of sideritic mudstones, sandstones and limestones, and constitutes a low grade, silicious iron ore. Green when fresh, the rock weathers to brown limonite exhibiting a characteristic 'box-stone' structure. The Northampton Sand lies with a slight angular unconformity on the Whitby Mudstone Formation (formerly Upper Lias), which consists dominantly of dark grey silty mudstone, weathering to silty clay. The Whitby Mudstone forms much of the steep, upper escarpment.

Towards the west, the slope of the upper escarpment flattens onto the bench formed by the Marlstone Rock Formation, which comprises a moderately strong, thinly bedded ferruginous limestone and sandstone. This formation was worked extensively for iron ore until a few decades ago. The workings in the adjacent parish of Fulbeck are at the extreme northern limit of the orefield and were of marginal economic viability. The fields from which the ironstone has been extracted are typically 1.5-2m lower than adjacent roadways and homesteads. The Marlstone Rock Formation is underlain by mudstones and siltstones with thin beds of sideritic ironstone or ironstone nodules. Formerly known as the Middle Lias, these strata have recently been included in the newly-defined Brant Mudstone Formation (Brandon *et al.*, 1990), which also encompasses the upper part of the former

'Lower Lias' subdivision. The Brant Mudstone forms the steep lower escarpment below the Marlstone Rock bench, and underlies the floor of the valley of the River Brant to the west.

Superficial Deposits. The steep surfaces of the upper and lower escarpments were affected by permafrost conditions during the Pleistocene glacial and periglacial periods. Frost shattered bedrock sheared and slipped repeatedly downslope, mantling the lower slopes of the escarpment with highly disturbed, soliflucted deposits known as Head.

As would be expected from the composition of the bedrock source materials cropping out upslope, the Head deposits generally comprise brown or grey weathered mudstone or clay containing sub-rounded to sub-angular, gravel-sized rock fragments (mainly of ironstone). Head deposits contain abundant internal shear planes with polished and slickensided surfaces. The thickness of the Head was generally expected to be up to 1.7m on the lower escarpment and up to 2.2m on the upper escarpment. Geotechnical tests showed the Head to be highly plastic and weak when wet.

Material classified as topsoil was present throughout the length of the proposed by-pass to typical depths of 0.3m and locally up to 0.4m. The topsoil was found to consist typically of a slightly gravelly, sandy clay, with limestone fragments common towards the eastern end of the route. Beneath the topsoil, the underlying Lias bedrock was weathered to a slightly sandy, very silty clay to a depth of 1.5-2m, underlain by fresh, comparatively unweathered mudstone.

Design

In designing the scheme, the Consulting Engineer had to take account of the fact that the bulk of the earthworks would be either excavated in, or constructed from, the mudstones of the Lias Group. These materials, whilst moderately strong in an undisturbed dry condition, rapidly become very plastic and weak when wet, and it was therefore essential to provide an effective drainage regime. Furthermore, it was readily apparent that the cutting design would have to allow not only for the surface water run-off after rainfall or snowmelt, but also the substantial discharges of groundwater that would otherwise issue out from the bases of the permeable rocks of the Marlstone Rock and Northampton Sand formations. The design solution involved the installation of a deep (up to 4m) cut-off filter drain around the perimeter of all cuttings. This consists of a deep trench backfilled with gravel-sized free drainage stone. At the top of the trench, a geotextile filter membrane that permits passage of water molecules but not clay or silt-sized particles is placed beneath the covering of topsoil to prevent the gravel from silting up. At the bottom of the trench, a pipe carries away any water collected. This is mostly discharged into the new road drainage system. However, for the part of the Fulbeck Hilltop cutting crossing the outcrops of the Lincolnshire Limestone, Grantham Formation and Northampton Sand, the discharge is fed beneath the new road into a 'seepaway' spillway. This was specially designed on site to maintain a natural flow downslope to water the profusion of Aconite flowers growing in the adjacent woodland (who says Engineers' do not have souls!).

In designing the earthworks, the Consulting Engineer employed a 'Factor of Safety' against failure, that resulted in cuttings in the weakest clays having sides with slopes as shallow as 1 in 5. In locations where it might be possible for seepages from minor aquifers to leak out and soften the clay slopes, the design called for lateral trench filter drains to be installed in the cutting sides. These were again protected from silting up by being enclosed in a geotextile membrane and were designed to outfall into the main longitudinal filter/carrier drains.

The main longitudinal filter drains run along either side of the new road and along the toe of the cutting slopes. They are designed to ensure that the water table beneath both the road and cutting slopes is maintained at a low level, and that the water collected is quickly discharged. They also accept and discharge any surface water shed from the carriageway.

The Head deposits masking the lower slopes of the lower scarp presented a potential problem for the road design in that they would lie beneath the approach embankment. Two options were considered:

1. complete removal, increasing the need for excavation and disposal off site and also requiring additional fill material to be imported;
2. stabilisation by installing a drainage system to maintain the material in a dry condition.

The Consulting Engineer opted for the latter solution, to be effected by a closely-spaced grid of filter drains (3.5m deep) through the Head deposits and into the mudstone bedrock beneath. These drains were also to be enclosed within a geotextile membrane and designed to outfall to the main longitudinal filter drains. The effectiveness of the filter drains was to be monitored by an array of piezometers (a device for measuring the head of water within a soil) to confirm that the water table was drawn down during and after construction of the embankment.

Whilst the above summarises the special artificial drainage measures necessitated by the geology of the escarpments, sympathetic use of the natural geological conditions permitted drainage to the east of the upper escarpments to be led down the dip slope away from the escarpment edge, before being discharged into soakaways excavated 5-6 metres into the Lincolnshire Limestone.

At the western end of the scheme, on the flat floodplain of the River Brant, a large pond was dug in impermeable Lias mudstone. The outfall from the pond was provided with a 'throttle' that restricts the rate of discharge from the road to the original natural discharge, to avoid overloading the existing roadside ditches that eventually outfall into the Brant.

Having determined the drainage required to maintain the existing soils and ground in as dry, and therefore strong, condition as possible, the design could then turn to consideration of the suitability of soil and rock materials excavated on site for construction of the embankments required by the scheme. A summary of the materials (and their properties) required for the various embankment and fill materials used during construction is given in Table 3.

From the site investigation conclusions, it was anticipated that 80% of the Lias silty clay/mudstone would, when tested again upon excavation, satisfy the criteria that would classify it as a wet cohesive or silty cohesive material suitable for use as a general fill (Class 2A, Table 3). It was anticipated that 90% of the Lincolnshire Limestone, Northampton Sand and Marlstone Rock would, upon testing on excavation, satisfy criteria to classify such material as uniformly coarse graded granular material, also suitable for use as general fill. The remaining proportions of the excavated material, including the Grantham Formation (variable sands and clays) were not expected to be suitable for use in embankment construction. The design allowed for their use as general landscape fill behind an environmental bund, to be constructed adjacent to the bypass to screen the road from Leadenham Hall. The harder limestone or ironstone beds were potentially suitable for crushing to give a graded material for use as a starter layer or fill or as a capping layer beneath the road construction (Classes 6B, 6F1, 6F2, Table 3).

At the point where the new Fulbeck bridge was to be built to carry the A607 over the new by-pass, the investigations had indicated that the foundation of the bridge would be in a very stiff silty clay/weak silty mudstone with a safe bearing capacity of 400kN/m^2. The design for the bridge foundations allowed for a worst case scenario (i.e. if all chainage measures failed and groundwater rose to within 2m of the ground level behind the abutment), providing a foundation that would induce a working load of only 190kN/m^2 with a settlement that would not exceed 15mm. The concrete to be used in the buried part of the bridge structure was designed to national guidelines set by the Building Research Establishment (1991) to resist chemical attack from groundwaters.

Construction

Upon completion of the proposed design work by the Consulting Engineer and its acceptance by the client (the Highways Agency), a contract for the construction of the works was put out to tender. The successful tenderer was given a commencement date of mid-February 1994 with a target completion date of July 1995. The Consulting Engineer was retained as Resident Engineer to oversee the construction of the road. (The author was a member of the Resident Engineer's site staff engaged upon this aspect of the scheme.) An on-site laboratory was set up and staffed to provide the Resident Engineer with materials-testing services and advice. In addition, the Resident Engineer could call upon a visiting Geotechnical Engineer for expertise on geotechnical aspects of the works.

Some minor delays in the progress of the contract were experienced in the first few months as a result of environmental protestors seeking to frustrate the works and it was not until April 1994 that earthworks got properly underway. Even so, the snowfall of February and the persistent showers of March (only 7 days without rain), meant that earthworks could only proceed upon the upland heathland of the Lincolnshire Limestone.

Attempts in mid-April to commence topsoil strip over the lowfields of the Lias clay had to be abandoned after 2 days because it was too wet; it was not possible to continue until a week later. This pattern of start-stop was to recur throughout the

Material	*Class*	*Intended Use*	*Total required (cubic metres)*
General Fill	1A, 1B, 1C, **2A**, 2D	General embankment construction	51,000
General and Landscaping Fill	1A, 1B, 1C, **2A**, 2D or 4	Noise bund construction	38,000
Topsoil	**5A**	Topsoiling	17,000
Selected granular fill	**6B**	starter layer	6,000
Selected granular fill	**6F1, 6F2**	capping layer	22,000

Table 3. Summary of the earthworks materials required during construction. Classes shown in bold indicate those encountered on the by-pass site. The classifications are determined in compliance with various geotechnical tests that measure material properties. *2A material* is a wet cohesive material, suitable for use as a general fill if it meets certain criteria with regard to its grading, plastic limit, moisture content, MCV Moisture Condition Value, and undrained shear strength of remoulded material. *5A material* is topsoil or turf suitable for re-use as topsoil provided its grading is such that it does not contain stones greater than 100mm diameter. *6B material* is selected coarse granular material suitable for use as a starter layer, consisting of natural gravel, sand, crushed rock, crushed concrete, slag etc. It must conform to a specified grading, be non-plastic and have fines with a strength characteristic of at least 50kN. *6F1 or 6F2 material* may be used as a capping material and (provided it complies with specified criteria for grading, optimum moisture content and fines strength value), is permitted to comprise any selected granular material, or combination of materials, other than unburnt colliery spoil, argillaceous rock or chalk.

earthworks programme because of the susceptibility of the Lias clay topsoil and subsoil to changes in moisture content. A rainfall of 14mm on 14th May, topped up by further rainfall of 20mm over 19th-21st May was sufficient to curtail earthworks until 6th June, when the clay escarpments and lowfields to the west eventually started to dry out. However, other works such as fencing and drainage could be continued throughout this period.

In April, the array of piezometer instruments to monitor the effect of drainage works beneath the embankment area were installed in readiness for monitoring the fall in groundwater during drainage installation and subsequent embankment construction.

In May and early June the A607 road was diverted away from the site of the new bridge. Use was made of the loadspreading capabilities of the Marlstone Rock Formation to provide foundations for the temporary 'Bailey' bridge (Fig. 2) that would carry the road over the cutting to be excavated beneath. The contractors initiative in providing this temporary bridge was a key element in shortening the contract period by several months. It enabled the A607 road traffic to be freed from conflict with construction vehicles, which could now pass from one side of the A607 road to the other by going underneath it.

The bridge excavations extended some 8 metres below the existing ground level and provided a good opportunity for examination of the Marlstone Rock Formation and the underlying Brant Mudstone Formation. The section was logged by Mike Sumbler and Hugh Ivimey-Cook of the British Geological Survey and published in an earlier part of this volume of *Mercian Geologist* (Sumbler and Ivimey-Cook, 1996). The site was visited by members of the East Midlands Geological Society as part of their excursion to the area on 3 September 1994. Fossils exposed in the lower part of the excavation included ammonites and bivalves (Fig. 3), the latter occurring in life position within a thin layer of sideritic, concretionary ironstone. These fossils were rapidly buried again as the mudstone floor of the bridge excavation was concreted over in order to maintain its dryness and strength, thus minimising the risk of wetting, softening and the potential for settlement.

As the road cuttings below the bridge were excavated down the escarpment slope to the west, three beds of sideritic concretionary ironstone were revealed in the sides of the cutting (Fig. 4), the uppermost of which corresponded to the bed uncovered in the bridge foundations (see above). Slight seepages of water were observed to emanate from these ironstones. Lateral filter drains were

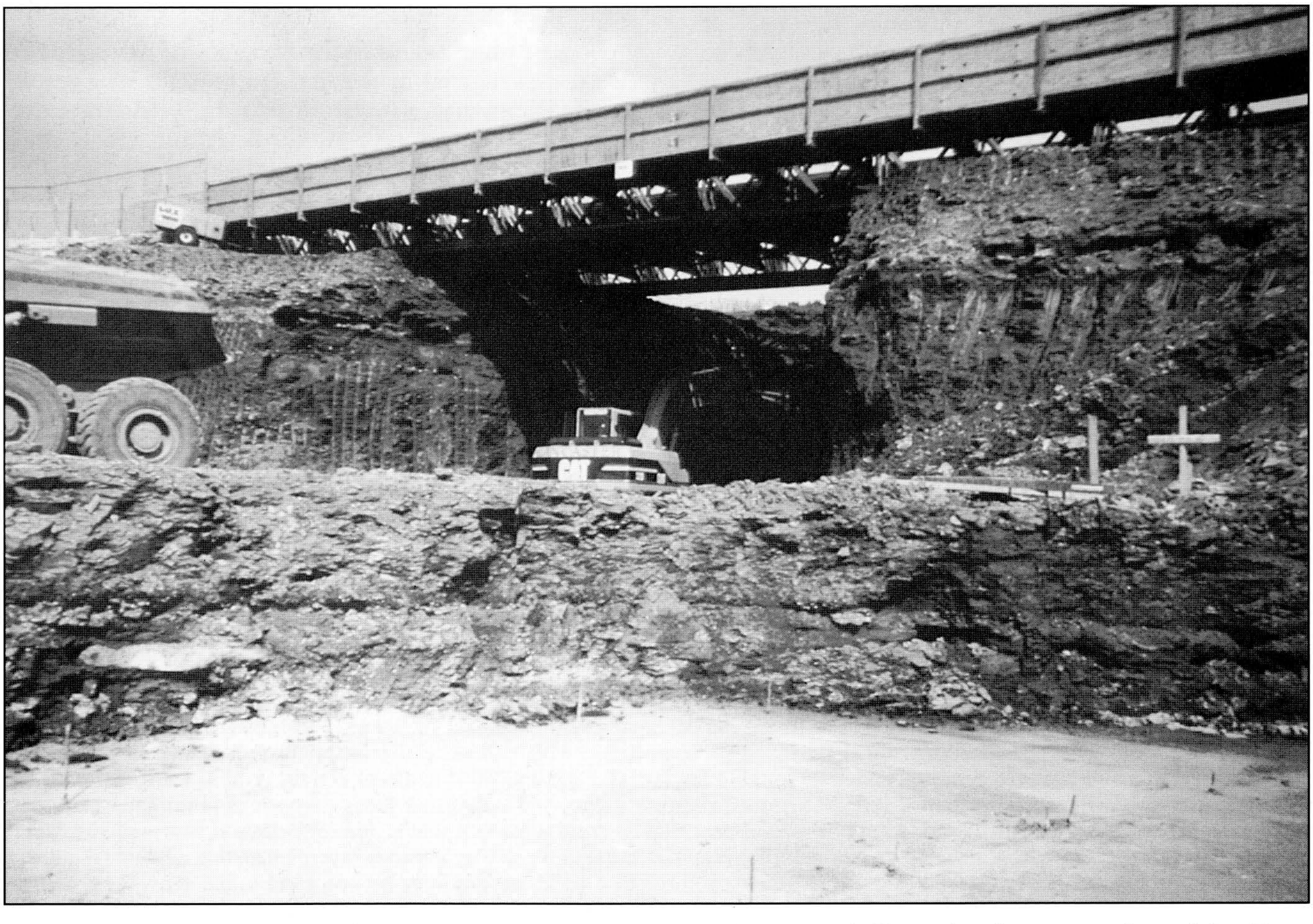

Fig. 2. Temporary overbridge of A607 road, supported on the Marlstone Rock Formation (upper strata) overlying Brant Mudstone Formation. The concreted foundation for the permanent bridge is in the foreground.

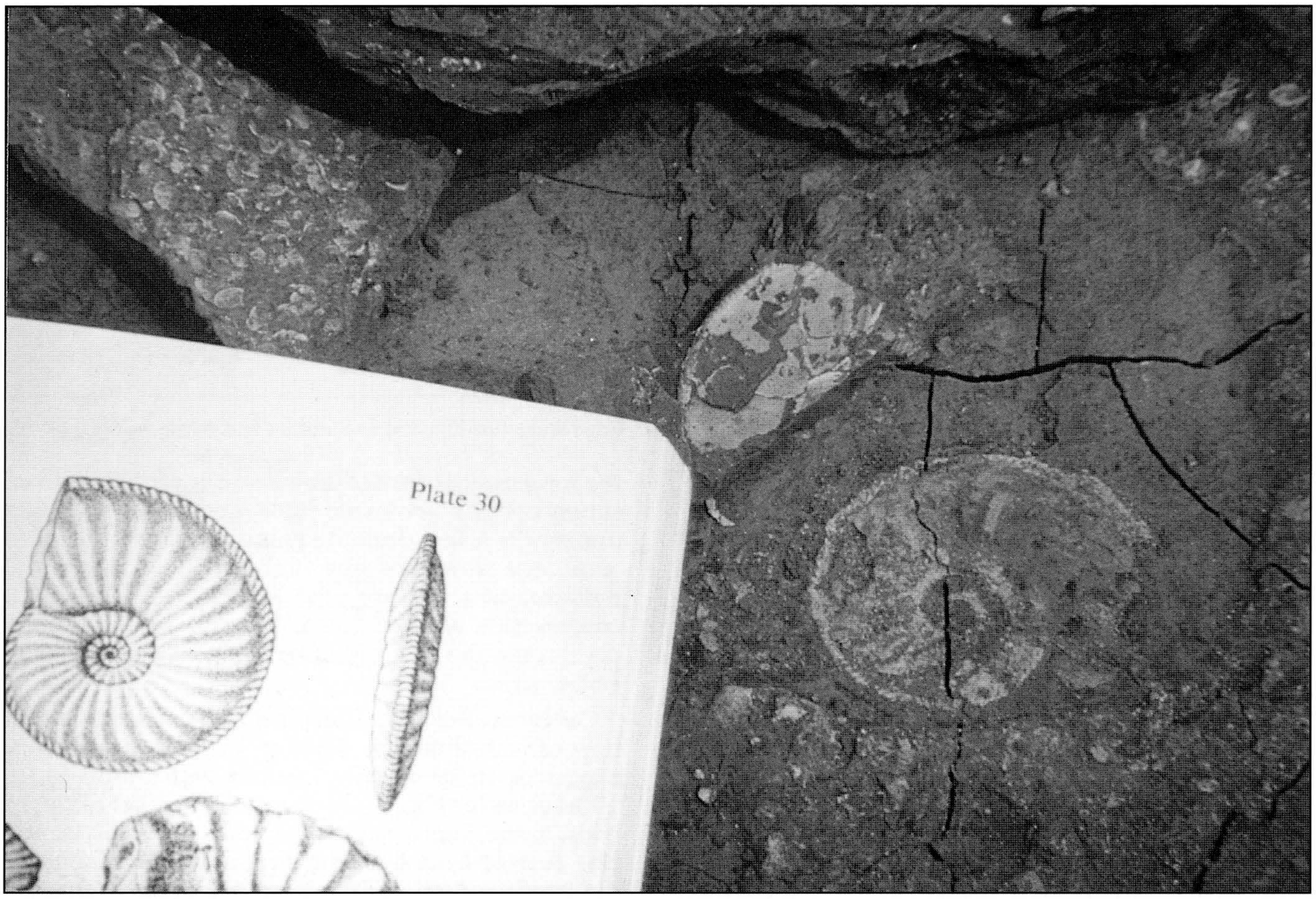

Fig. 3. Ammonites and bivalves exposed on the floor of the bridge foundation excavations before concreting over.

installed in the cutting sides to drain these spring lines and to lead the water away into the longitudinal carrier/filter drains, in order to prevent softening of the mudstone slopes and eliminate the risk of failure by slipping. Similar treatments were subsequently applied to other sources of potential spring lines, principally the Marlstone Rock Formation outcrop in the Mill House Cutting sides to either side of the A607 bridge and the Northampton Sand outcrop in the Fulbeck Hilltop cutting (Fig. 5) at the top of the upper escarpment.

During installation of the grid of transverse filter drains, designed to lower the water table below the Head deposits underlying the embankment at the foot of the lower escarpment (Fig. 6), it became obvious that these deposits were not as thick as anticipated and that the underlying mudstone was so impermeable that drawdown of the water table within it was difficult to achieve. The design was therefore reviewed to reduce both the frequency of the drains and their depth of penetration into the mudstone. This enabled acceleration of the construction works and substantial cost savings. Head deposits encountered on the side of the long, shallow cutting in the lower slopes of the upper escarpment were mostly removed during excavation,

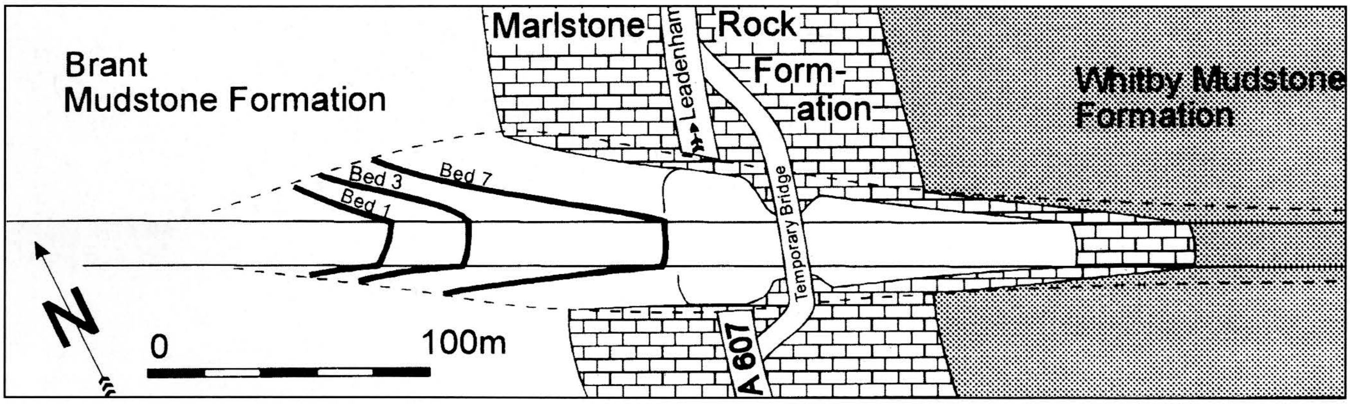

Fig. 4. Geology of the Mill House cutting in the lower Lincoln Edge scarp, showing outcrop of concretionary ironstone beds (1, 3 and 7) in banks of cutting (modified after Sumbler and Ivimey-Cook, 1996).

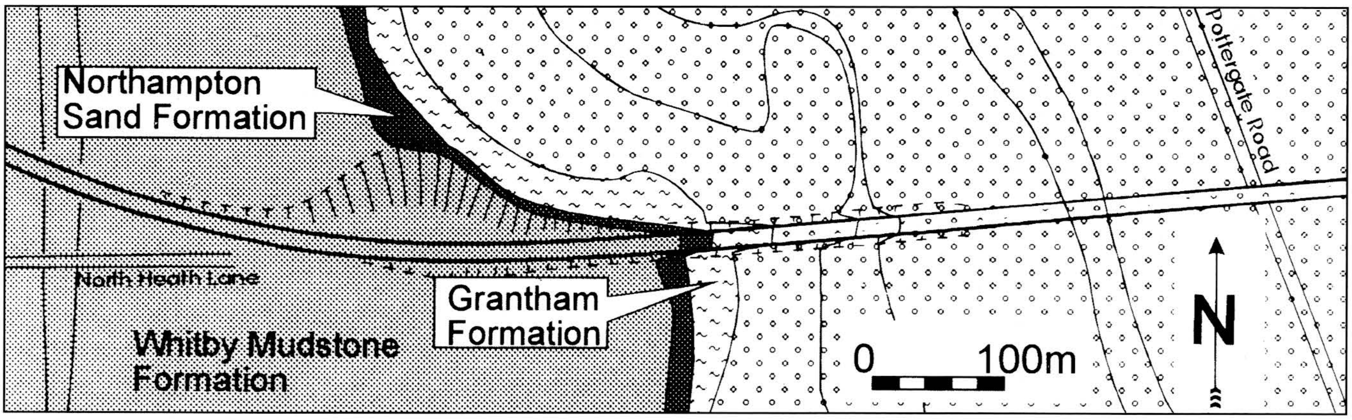

Fig. 5. Geology of the Fulbeck Hill top cutting in the upper Lincoln Edge scarp (modified after Sumbler and Ivimey-Cook, 1996).

but some further excavation in localised areas (softspots) was required before replacement with a granular fill material.

During construction, large quantitites of granular fill material (Table 3) were required as both a starter layer and capping material. Although the Consulting Engineer had been aware in his design that the Contractor could have won some of this material from the limestone and ironstone to be excavated from the site, the Contractor decided that, bearing in mind the cost of crushing, the quantities available were insufficient for cost-effective use. All granular fill material was thus imported from a local Lincolnshire Limestone quarry. The starter layer material acts as a chainage blanket to drain down the foundation of the embankment (it is connected to the longitudinal carrier drain) and is protected from silting up by a geotextile filter membrane. Capping material is a free-draining granular material used to 'cap' the floor of the cutting or top of the embankment before the layers of the road construction are laid down. It assists in providing a dry foundation to the road by being connected to the carrier drain.

On excavation, the Lincolnshire Limestone at the top of the Fulbeck Hilltop cutting proved, as expected, to be heavily fissured with joints up to 100mm wide (Fig. 7). In the more weathered upper beds, these joints were filled with a gravelly sandy clay derived from both the weathered limestone and the overlying soil. The joints were open in the less weathered, moderately strong limestone beds at

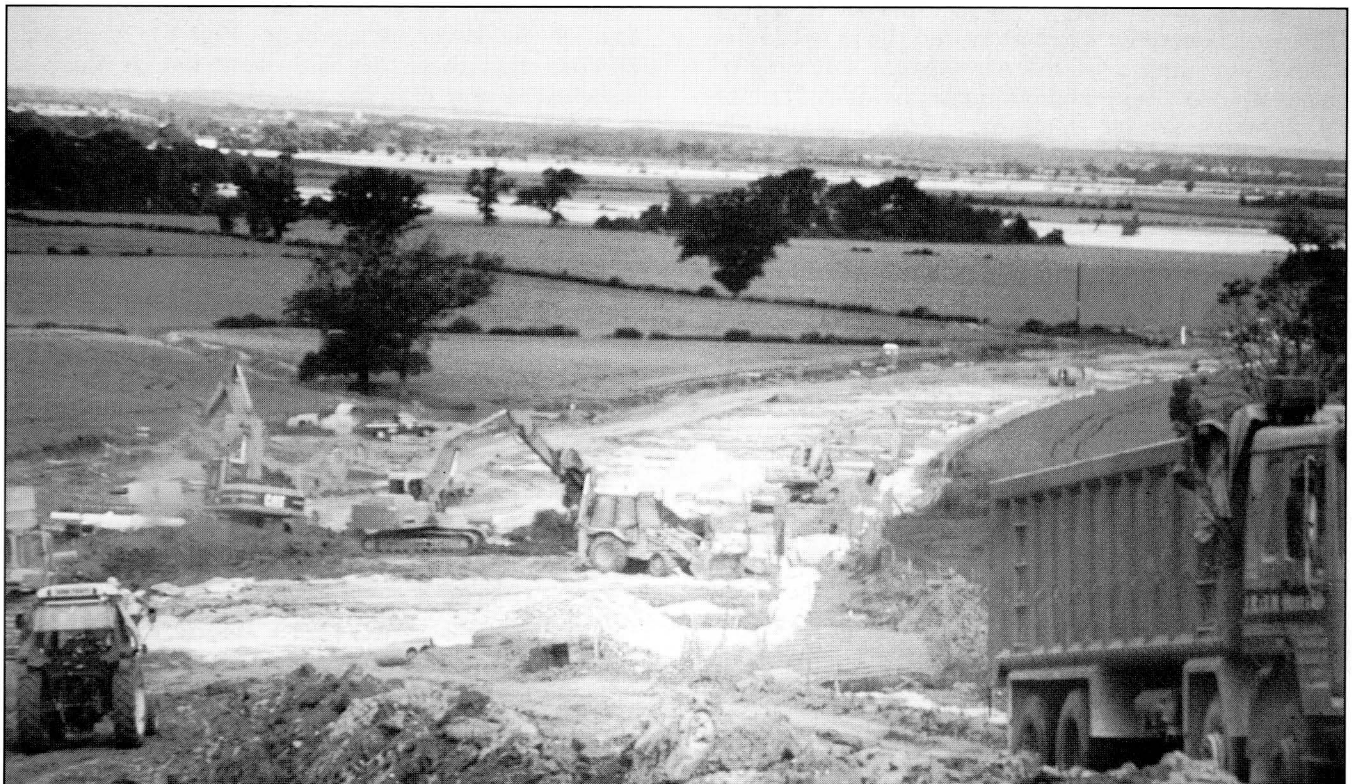

Fig. 6. Installation of the drainage system to de-water head deposits before construction of the embankment.

depth. The open joints were found to parallel the NW-SE direction of the strike of the bedding planes and the alignment of the scarp edge at this location. Here, on the very edge of the escarpment, the beds were found to dip at up to 10 degrees towards the south or south-west, whereas on the dip slope the dip was measured as 1-2 degrees to the east. This is a textbook example of cambering, induced by spring sapping of the Grantham Formation sands and clays by groundwater issuing from the base of the Northampton Sand Formation. It was concluded that the existence of the open joints was unlikely to have any effect on the stability of the cutting since they were at an oblique angle to it. However, their width demanded that they should be grouted up with weak concrete and capped over prior to road pavement construction, to avoid the possibility of localised depressions. Though this entailed a slight additional cost to the scheme, the fissuring (after soakage tests) permitted the number of large diameter 6 metre deep soakaways, designed to be constructed at the eastern end of the scheme (see above), to be substantially reduced.

Fig. 7. Joints up to 100mm wide in Lincolnshire Limestone. These trend parallel to the valley side at the top of upper escarpment, and have opened up as a result of cambering of the Limestone.

Conclusion

The author counts himself fortunate to have been involved with the engineering of a roadworks site that encountered a range of rarely-exposed strata of Lower and Middle Jurassic age. Although the differing geotechnical properties of the various geological formations demanded careful consideration and appropriate engineering solutions, these same properties could in many cases be turned to advantageous and imaginative use to solve some of the problems that arose during construction. The new road not only relieved the village of Leadenham of the nuisance and danger of heavy traffic but also provided an excellent opportunity for geological field study of these rocks by groups such as the East Midlands Geological Society and the Stamford and District Geological Society. The exposures have also provided considerable information on the otherwise poorly-exposed Lias Group strata of this part of Lincolnshire, greatly increasing geologists' knowledge and understanding of regional Lower Jurassic stratigraphy. Furthermore, it has encouraged the workforce engaged on the scheme and the local population (who have asked for a collection of the local fossils found on the site to be displayed in Fulbeck church) to take an interest in and find out more about the geology of the area.

References

Brandon, A., Sumbler, M. G. and Ivimey-Cook, H. C., 1990. A revised lithostratigraphy for the Lower and Middle Lias (Lower Jurassic) east of Nottingham, England. *Proceedings of the Yorkshire Geological Society*, **48,** 121-141.

British Geological Survey, 1972. *Grantham.* England and Wales Sheet 127 (Solid and Drift Geology, 1:50,000 Provisional Edition). Ordnance Survey for Institute of Geological Sciences.

British Geological Survey, 1996. *Grantham.* England and Wales Sheet 127 (Solid and Drift Geology, 1:50,000). Keyworth, Nottingham, British Geological Survey.

British Standards Institute, 1975. *BS1377. Methods of test for soils for civil engineering purposes.*

British Standards Institute, 1981. *BS5930. Code of Practice for Site Investigations.*

Building Research Establishment, 1991. *Sulphate and acid resistance of concrete in the ground.* BRE Digest 363.

Chandler, R. J., 1981. Lias Clay slope sections and their implication for the prediction of limiting or threshold slope angles. *Earth Surfaces Processes and Landforms*, **7,** 427-438.

Sumbler, M. G. and Ivimey-Cook, H. C., 1996. Temporary sections in Jurassic strata near Leadenham, Lincolnshire. *Mercian Geologist*, **14,** 4-11.

Peter Green
6 Washdyke Lane
Leasingham
Lincolnshire
NG34 8LT