Report

The benefit of using geosynthetic asphalt reinforcement in road maintenance plans

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creative geosynthetic engineering

Report

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Report

Foreword

This report has been compiled by ABG Geosynthetics Ltd, Meltham Mills Road, Meltham, West Yorkshire in conjunction with Kirklees Council, as part of a collaborative long term trial of a Geosynthetic Composite Asphalt Reinforcement interlayer placed within the road surface of Meltham Mills Road, Meltham.

The entire road was fully resurfaced from binder course to surface course, and Kirklees Council agreed to the Geosynthetic Composite being introduced to a trial section over a discrete area where it was predicted the heaviest trafficking of the road would occur. After 10 years of heavy trafficking on this busy industrial estate access and town by-pass road, the surface is showing distinct signs of distress in certain areas.

This report analyses various data alongside a comprehensive visual site survey plotting the reinforced and non-reinforced areas of the site showing the beneficial effect of crack reduction afforded by the Geocomposite. A cost benefit analysis based on this report is included in line with Kirklees Asset Management Approach for Highways Infrastructure, which looks for proven innovative techniques on extending road maintenance periods, whole life performance and preventing pothole formation.

Figure 1 – Meltham Mills Road Inlay Installation

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Background to Trial

Asphalt Pavements

Deterioration of constructed asphalt pavements is natural, because over time the materials that make up asphalt begin to break down and become affected by elements such as rain, sunlight and chemicals that come into contact with the pavement surface. The liquid bitumen binder that is the "glue" of the pavement begins to lose its natural resistance to water, allowing it to penetrate into and underneath the pavement. Once this happens, the surface can quickly fall prey to a number of different types of deterioration.

Deterioration of asphalt pavements can also be due to factors that go beyond just normal wear and tear causing premature deterioration. The premature deterioration of asphalt pavement is usually due to failures in construction or human error. This can be due to a number of factors including:

- Insufficient or improperly compacted base below the asphalt.
- Sub-grade failure and associated rutting.
- Over or under compaction of asphalt.
- Improper temperature of asphalt when applied.
- Poor drainage.
- Asphalt deterioration.
- Asphalt rutting associated with permanent asphalt strain.

For clarity, this document is concerned with addressing pavement defects caused by reflective cracking. Failures and degradation resulting from other circumstances are **not** addressed.

Geosynthetic Asphalt Reinforcement

The maintenance of roads in the UK has always been a challenge due to heavy trafficking and variable weather conditions. Many types of treatments have been used to extend the service life of asphalt roads with a view to minimising maintenance costs. Breakdown of the road surface is caused by weathering, movement and fatigue, and can be accelerated by the asphalt's susceptibility to reflective cracking.

Cracking in asphalt pavements is therefore recognised as one of the biggest problems faced by highway maintenance engineers. As the surface degrades, microscopic cracks can develop to become potholes, ravelling and other modes of failure. The consequence of this may simply be minor inconvenience for users, but can be much more serious, for example causing drivers to swerve, damage to vehicles and reduced grip on loosened surface material.

The harm to highways authorities of such deterioration can be significant, in terms of claims for damages, loss of reputation and repair costs, so whilst a maintenance regime is undoubtedly costly, it is a critical aspect of keeping the network serviceable and avoiding bigger costs. Any way to extend the maintenance intervals can represent significant savings in the whole life cost.

A range of possible solutions increasing the life of a pavement might include: mill and inlay, application of thick asphalt overlays, the use of modified asphalt mixtures containing high polymer modified bitumen content and the application of an interlayer for stress-absorption (SAMI), or reinforcement systems. Combinations of these solutions are, of course, also possible. During the design phase of a project, each potential solution needs to be assessed in terms of the whole life cost benefit before deciding on the most appropriate maintenance option. Kirklees B.C. have been using asphalt grouted macadams in high stress areas.

Long Term Asphalt Reinforcement Trial
Meltham Mills Road, Meltham, West Yorkshire

Report

One of the treatments which has been used extensively over the past 30 years in the UK and globally is the use of an asphalt stress-absorption interlayer (SAMI), which is installed within the pavement to intercept the path of a crack propagating through the pavement. When placed between bituminous-bound layers or between concrete and an asphalt overlay, these products retard the initiation and propagation of reflective cracking which leads to premature pavement failure. These are usually supplied as a rolled product in different forms consisting of different raw materials.

Asphalt reinforcement systems have a long track record of successful use, with over 2.7 million m^2 used annually in the UK (2017 industry data), and more than 100 million m^2 installed throughout Europe since the 1980's. Over this period the industry has continuously improved its products, systems and installation techniques and captured evidence of performance. ABG has been involved in developing the Road Surface Treatment Association (RSTA) Code of Practice for the installation of asphalt reinforcement. It is worth noting that the majority of UK local authorities have now used these systems as they have grown in acceptance, and there is much objective and anecdotal evidence to support their benefits.

Benefits include:

- Delayed re-occurrence of reflective cracking.
- Longer pavement service life.
- Reduced maintenance interventions.
- Reduced environmental impact associated with longer maintenance intervals.
- Reduced hidden costs to businesses and the public through fewer road closures and traffic restrictions.
- Reduced embodied carbon.

As well as financial, there are environmental savings associated with an extended maintenance interval. There are significant environmental costs associated with the manufacturing, transport and placement of asphalt, as well as the disposal of arisings when the old surface is removed.

The potential environmental savings and enhanced whole life cycle of the reinforced pavement structure have been studied and evaluated by independent organisations such as Transport Research Laboratory (TRL), academia such as Nottingham Asphalt Research Consortia (NARC) working out of the University of Nottingham, and industry bodies such as the Road Surface Treatments Association (RSTA). Their research has embraced increased road life expectancy, alternative installation methods, cost benefits, and more recently, research on carbon footprint implications. Please contact ABG for more information.

Figure 2 - Typical Rotaflex installation build up

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Meltham Mills Road Trial Area

It was known before the trial took place that Meltham Mills Road is a particularly busy road as it serves a large industrial estate and also acts as a road bypass for Meltham used by local and through traffic. ABG staff report that during the day it is often hard to cross the road due to the volume of traffic, and drivers take advantage of the road to avoid Meltham town centre. A reasonably high number of HGV vehicles serve the industrial estate. In particular, the ABG factory and neighbouring Camira factory share an apron where there is significant HGV manoeuvring in the entrance area of both factories.

2010 Resurfacing and Rotaflex Installation

In November 2010 the whole of the Meltham Mills Road was planned to be planed 100mm and resurfaced. A new binder course would be placed and overlain with a new surface course. Before placing the surface course a discrete trial area of Rotaflex was to be installed in order to closely monitor performance over a long period.

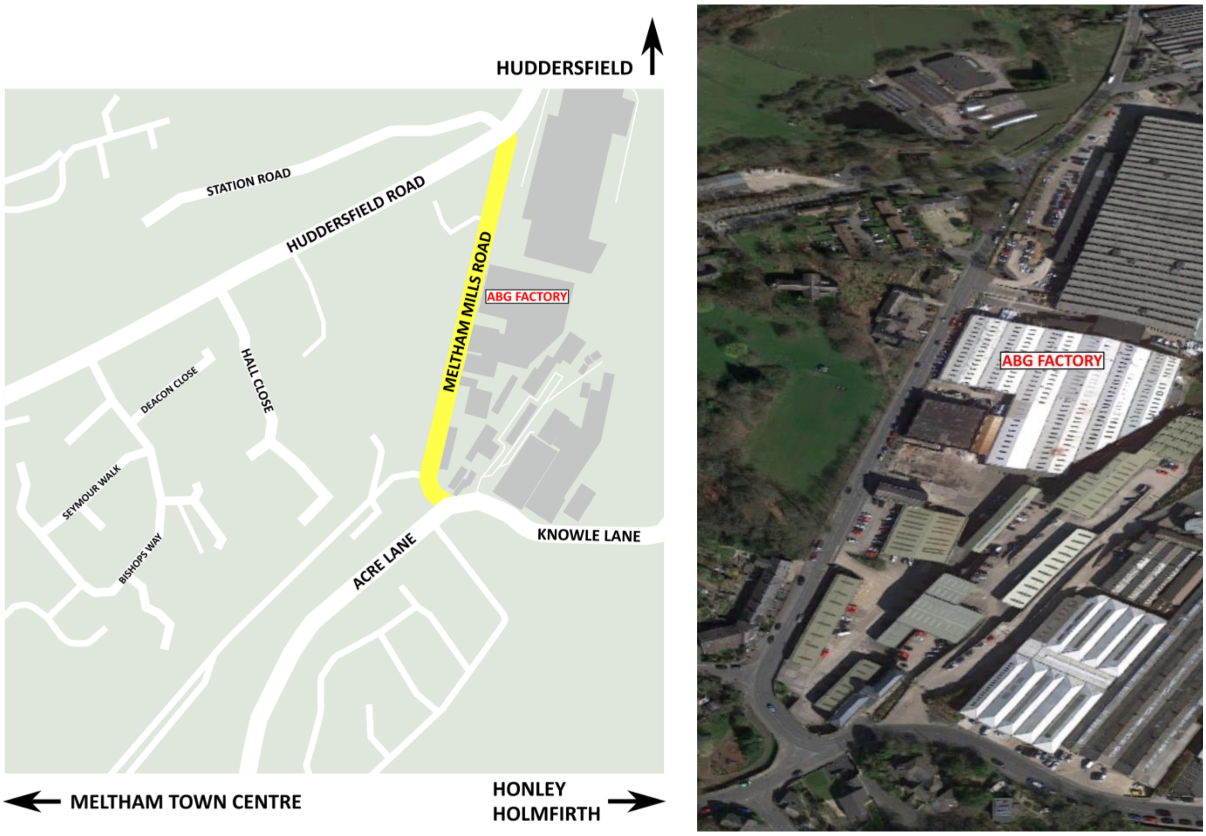

Figure 3 – Meltham Mills Road showing area to be resurfaced

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2009 Distressed road ready for surface replacement

Figure 4 – alligator cracking

Figure 5 – alligator cracking in trench line

Figure 6 – edge of trench reflective cracking

Figure 7 - multiple trench reflective cracks

Figure 8 – surface differential settlement

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Selection of Trial Area

The Rotaflex was placed overlapping the main entrance to ABG's production facility, where the majority of deliveries and despatches to and from ABG are handled. HGVs frequently and regularly complete slow manoeuvres in this area to access our loading yard.

The Rotaflex then extends south flanking the factory along Meltham Mills Road. This stretch was selected as the southern edge of an area which is heavily trafficked by HGV and other traffic accessing the rest of Meltham Mills Industrial area or by-passing the town centre, and is easily monitored by ABG.

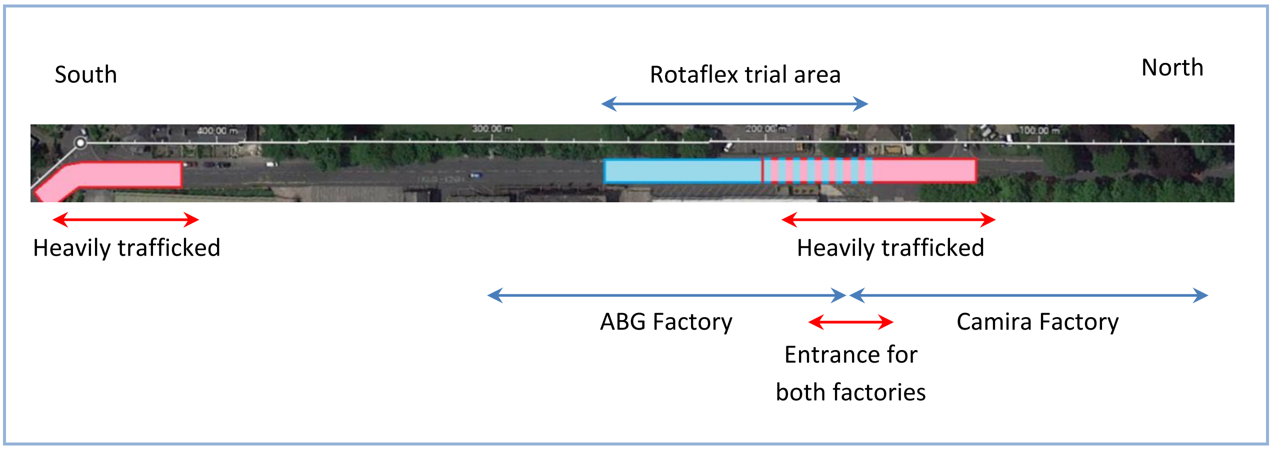

Figure 9 – Rotaflex trial location

The heavily trafficked areas are shown above, at the north end, where deliveries are to both main factories and at the south end, where a downhill section of road combined with a bend receives heavy loading.

Figure 10 – ABG and Camira apron subject to frequent HGV maneouvring

Figure 11 – Typical traffic loading throughout the working day

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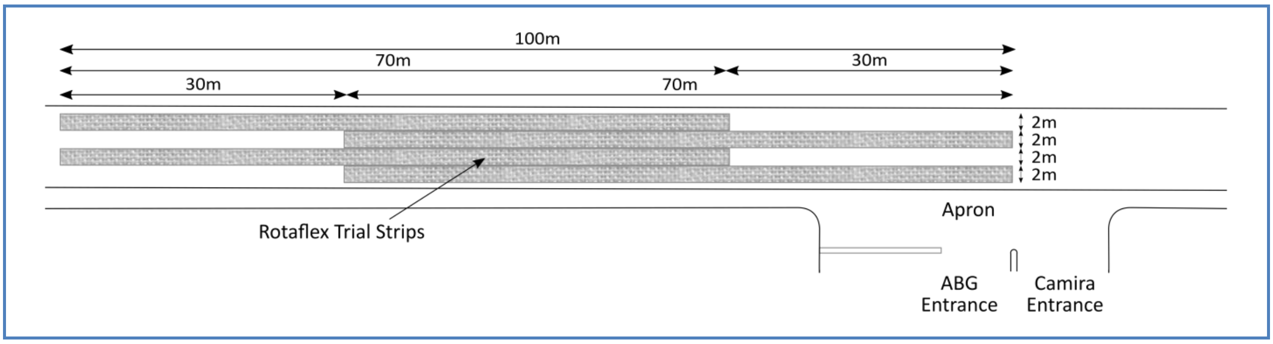

Figure 12 – Detail of Rotaflex trial strip position

Figure 13 – Milling surface down to setts

Figure 14 – Close to finished formation

Figure 15 – Stable milled surface ready to receive binder course

Figure 16 – Rotaflex ready to receive surface course

Figure 17 – Laying machine placing Rotaflex across ABG entrance

Figure 18 – Installing surface course onto Rotaflex

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Performance Assessment

Value for Money

A useful way of comparing the effectiveness of asphalt reinforcement systems is to express performance in terms of a 'cost life index'. This is the cost per m^2 of the work divided by the service life in years. It provides a measure of 'value for money' which the highway authority is achieving. A low 'cost life index' and high 'value for money' result from specifying high-quality materials and workmanship.

To quantify performance ABG has collated various sources of information in order to allow comparative assessment with other sites.

Camera survey

A time lapse camera was mounted on the wall at the entrance to the ABG factory to monitor vehicle movements throughout the day on the apron area, as well as through traffic on Meltham Mills Road. This allowed an accurate vehicle movement count to be carried out.

The video was taken on the 1st December 2018 which was a typical day for local traffic, and a low season day for ABG as the company supplies the construction industry which is quieter during winter months.


Figure 19 – Time lapse camera to survey traffic levels at ABG entrance

Car and Van movements Meltham Mills Road
Survey date 01/12/2018

	Time start	Count	Time (mins)	Av Count /hr
1	10:00	100	15	400
2	11:00	100	16	375
3	12:00	100	17	353
4	13:00	100	15	400
5	14:00	100	13	462
6	15:00	100	13	462
7	16:00	100	12	500
8	17:00	100	13	462
9	18:00	100	13	462
10	19:00	100	22	273
11	20:00	100	25	240
12	21:00	100	30	200
13	22:00	100	60	100
14	23:00	83	60	83
15	00:00	17	60	17
16	01:00	14	60	14
17	02:00	12	60	12
18	03:00	8	60	8
19	04:00	7	60	7
20	05:00	6	60	6
21	06:00	60	60	60
22	07:00	100	20	300
23	08:00	100	12	500
24	09:00	100	12	500
			Total	6,193.82 per day
				2,260,745 per year
				11,303,726 5 years
				22,607,451 10 years

Table 1 - Vehicle count survey data from time lapse camera

The count was made from the time lapse camera for the first 100 cars in each hour and adjusted for the average cars per hour. Peak flows reached 8 vehicle movements per minute. In addition to the car and van movements, there were 189 HGV vehicle movements.

	Per day	Per year	Per 10 years
Car & van	6005	2192k	21918k
HGV	189	69k	690k
Total	6.2k	2381k	22608k

Published statistics suggests that this is 3 times the average vehicle flow for a Minor Urban Road (see Table 2) for Yorkshire and Humberside.

Shown above in figure 19 is a typical scenario where a vehicle is being loaded while two wait to either be offloaded or loaded having either parked on the road surface or manoeuvred over it to wait in the loading bay of the factory.

Meltham Mills Road can therefore be considered heavily loaded by the number of cars and the HGV movements, especially in the area outside the factory gates where there are regular and frequent low speed manoeuvres for loading and unloading.

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Department for Transport Statistics

Compared with average DfT motor vehicle flow for urban minor roads for Yorkshire and Humberside, Meltham Mills Road has **3 times** the average loading for this type of road. Meltham Mills Road would normally be classed as a minor urban road with average flow of 1.9 thousand vehicles per day. Results from the time lapse camera suggest 6.2 thousand vehicles per day which is equivalent to all matches all major A class roads for Scotland.

This confirms that Meltham Mills Road receives a heavy loading and a lower than average maintenance period and therefore higher costs would be expected.

Department for Transport statistics

Traffic (www.gov.uk/government/organisations/department-for-transport/series/road-traffic-statistics)

Table TRA0302

Motor vehicle flow by road class and region and country in Great Britain, 2017 [1]

Thousand vehicles per day

	Major roads					Minor roads			
		'A' roads							
	Motorway [2]	Rural	Urban [3]	All 'A' roads	All major roads	Rural	Urban [3]	All minor roads	All roads
North East	57.3	15.9	20.4	17.0	18.2	0.7	2.1	1.3	**3.3**
North West	80.4	11.6	16.7	13.6	23.0	1.0	1.9	1.5	**4.2**
Yorkshire and the H	75.8	12.8	18.2	14.4	21.2	1.0	1.9	1.4	**3.8**
East Midlands	96.2	15.4	18.7	16.0	19.9	1.1	2.1	1.4	**3.8**
West Midlands	84.9	12.9	19.7	14.9	22.7	1.0	2.4	1.6	**4.2**
East of England	103.3	20.6	18.9	20.3	25.6	1.4	2.7	1.8	**4.3**
London	114.3	34.4	26.1	26.7	29.6	1.1	2.2	2.2	**5.5**
South East	99.6	19.2	18.8	19.1	28.1	1.5	2.3	1.8	**5.1**
South West	79.7	12.4	18.5	13.3	17.4	0.9	2.3	1.2	**2.9**
England	87.6	15.4	19.8	16.6	22.8	1.1	2.2	1.6	**4.1**
Wales	72.6	9.0	17.6	10.0	12.1	0.6	1.9	0.9	**2.4**
Scotland	47.8	4.9	15.3	6.2	8.0	0.5	1.7	0.9	**2.2**
Great Britain	**82.1**	**12.1**	**19.2**	**13.8**	**18.7**	**1.0**	**2.1**	**1.4**	**3.6**

1 The calculation for the average daily flow is estimated by dividing the annual traffic estimate by the road length and the number of days in the year.
2 Includes trunk motorways and principal motorways
3 Urban roads: Major and minor roads within an urban area with a population of 10,000 or more. These are based on the 2011 Cenus definitions of urban settlements.

Source: DfT National Road Traffic Survey
Last updated: July 2018
Next update: June 2019

Table 2 - DfT Road use statistics

SCANNER Surveys

Surface Condition Assessment of the National Network of Roads (SCANNER)

Kirklees Council provided SCANNER survey results in November 2018. The plot below shows one of the outputs from the dataset gathered: Longitudinal Profile of the road. This is an average of the nearside and offside wheel paths measured at 10m centres along the Meltham Mills Road.

Figure 20 – SCANNER crack survey mapped to Rotaflex installation
(Note: no reading over the Rotaflex protected area for either carriageway)

Figure 21 – The SCANNER survey vehicle

The survey output shown above used the SCANNER Survey System. One side of the road is surveyed in any one year. The two scan lines show the two sides of the carriageway. The factory side (eastern) was scanned in 2017/2018 and the opposite side 2018/2019. The peak value just to the north of the factory entrance in the heavily trafficked area showed 2% cracking.

Road Condition and Maintenance data (DfT) – Area of Cracking definition

SCANNER survey vehicles use downward facing cameras to continuously collect images of the road surface. The video images are processed through automatic crack detection software. The cracking is reported as a "crack map" which describes the transverse and longitudinal position of each crack, the length of each crack and the angle of the crack relative to the direction of travel.

The measurement of cracking typically covers a survey width of 3.2m, although this can vary with the survey vehicle (the minimum requirement is 2.9m). The area of cracking is obtained by overlaying the crack map with a 200mm grid covering the whole survey width, and counting the number of grid squares containing cracks. The area of cracking over each 10m length is reported as a percentage measure.

The automatic detection of cracking is a demanding task for computer processing systems, and the software employed is subject to a process of continuous improvement to help improve confidence in the cracking data. However, the measurement of cracking is still subject to a degree of variability.

Mapping of Rotaflex trial location to SCANNER results

The Rotaflex installation area (blue) and highly trafficked area (pink) show correlation with SCANNER results. There are obvious deformations in the unreinforced (no Rotaflex) heavily trafficked zone (pink). There is no notable deflection in the heavily trafficked reinforced (Rotaflex) zone (blue/pink strips). Note the northern end of the Rotaflex zone is where the isolated strips occur and the cracking on the ground shows the distress is in the **unreinforced** area. (see Figures 20 and 22)

The Rotaflex has made a demonstrable difference to the cracking deterioration of the Meltham Mills Road.

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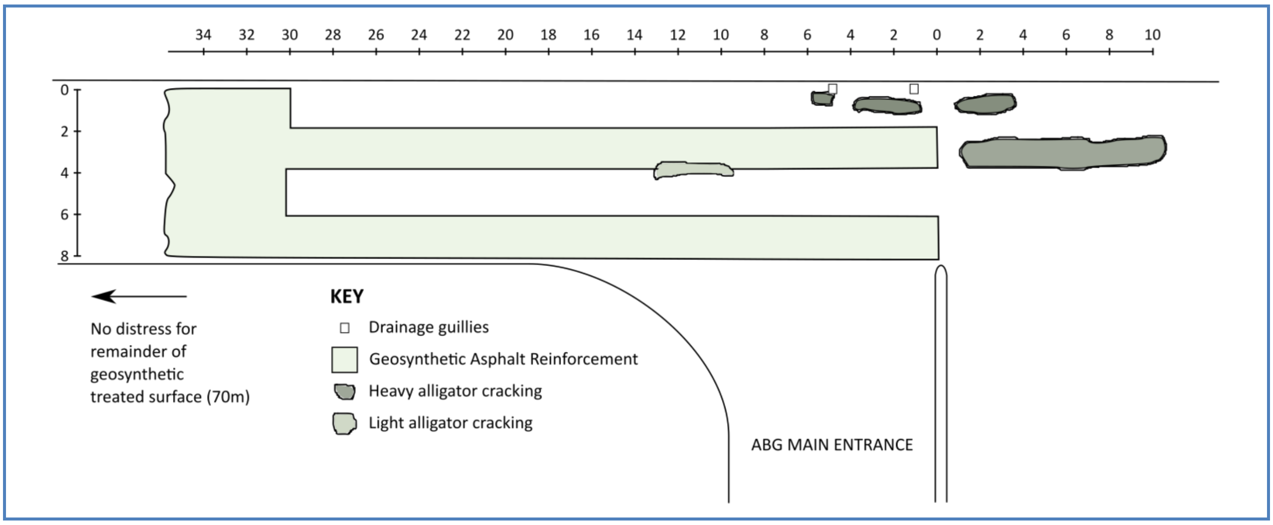

Figure 22 – Visual survey of Northern end of Rotaflex installation at 15/11/2018

Comparison Road

Great Northern Street, Huddersfield, West Yorkshire

Great Northern Street was resurfaced in December 2004 over setts and showing no damage.

Coverage:	Full road using Rotaflex
Formation:	Setts
Traffic loading:	Urban classed road serving busy industrial area with HGV traffic to large timber merchant.
Maintenance:	None over 15 year period, no sign of any need for treatment

Figure 23 – No sign of distress after 15 years heavy loading

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COST BENEFIT ANALYSIS

Having established that the Rotaflex has made a notable difference to the maintenance period by extending the life of the road by preventing crack propagation it is now possible to make a cost comparison between reinforced and unreinforced roads over the lifespan of the road between resurfacing operations.

Maintenance Costs

Kirklees Council target maintenance costs for resurfacing, patching and surface dressing as follows

% Patch	10%	15%	20%	25%	30%
Resurface	£35.00	£35.00	£35.00	£35.00	£35.00
Patch	£3.50	£5.25	£7.00	£8.75	£10.50
Surface Dress	£4.75	£4.75	£4.75	£4.75	£4.75

Note: The price is per m^2 of total road surface needing patching.

Table 1 – Target Costs for treatment types per m^2 (2019)

Using the evidence built from the Meltham Mills Road site and confirmed by other Rotaflex installations in Kirklees Borough, e.g. Great Northern Street; realistic maintenance periods can now be used.

For comparison purposes we have also projected expected maintenance, again assuming 3 year intervals for both the areas with Rotaflex vs those without. The table assumes a 5,000 m^2 area, and includes surface dressing after 15 years to remediate the loss of grip due to surface polishing on the Rotaflex area.

			Costs without Rotaflex				Costs with Rotaflex			
Activity	Time interval	Cum. time	cost per m^2 (2019 costs)	costs for total road surface (2019 costs) (m^2) 5000	Cum. Total Costs (2019 costs)	Activity	cost per m^2 (2019 costs)	costs for total road surface (2019 costs) (m^2) 5000	Cum. Total Costs (2019 costs)	Cumulative Comparative Total costs difference
Resurface	0	0	£35.00	£175,000	£175,000	Resurface	£40.00	£200,000	£200,000	-£25,000
Patch 10% + Surface Dress	9	9	£8.25	£41,250	£216,250		£0.00	£0	£200,000	£16,250
Patch 25% + Surface Dress	6	15	£13.50	£67,500	£283,750	Surface Dress	£4.75	£23,750	£223,750	£60,000
Requires resurfacing	6	21	£0.00	£0	£283,750	No treatment needed	£0.00	£0	£223,750	£60,000
									Saving	**21%**

Table 2 - Estimated maintenance costs

Notes

1. Evidenced by the monitored trials and from experience at Kirklees a newly surfaced road should last an average of 9 years before needing treatment.
2. Patching rates are based on Kirklees experience of this type of road.

3. This analysis does not take into account the extended lifetime of the Rotaflex reinforced road. Evidence shows this could extend by a further 5 years before the road needs resurfacing. This extends the maintenance period still further.
4. The price of Rotaflex installed includes the geotextile plus the bitumen spray binder along with machine and mobilisation costs. The process is in line with ordinary resurfacing operations and does not cause delay or cause any further costs to the operation. Total costs for the inlay is £5/m^2 at 2019 prices.
5. No account has been taken for increase cost in all materials over the 21 years considered. The saving on material costs will be significantly more than those illustrated resulting in even greater savings.
6. With reduced numbers of maintenance events the hidden reduction in costs to businesses and road users is also considerable and has not been considered.

The benefit of Geosynthetic Asphalt Reinforcement

Based on this long term study it is clear that Rotaflex has provided a significant cost benefit during this assessment period. The initial cost to install the Rotaflex was around £5 per m^2, and by year 6 this cost has been recouped by the reduction in maintenance required. Comparing a 22 year lifecycle for an unreinforced maintained road with a 26 year lifecycle Rotaflex reinforced road the saving in maintenance costs alone are 21%. It is estimated overall costs will be over 50%.

CONCLUSION

Kirklees Borough Council Highways Department with ABG have carried out a credible and long term closely monitored trial on the Meltham Mills Road. It is normally very hard to monitor a road due to resources and accessibility along with the risk of ad hoc maintenance caused by utility companies which can obscure results. SCANNER results confirm that the areas which are now showing distinct distress are the unreinforced areas of the road. Comparison Rotaflex reinforced sites have supported the findings at Meltham Mills Road showing extended maintenance periods above those experienced normally in the Borough. This then established a likely maintenance regime using a Rotaflex reinforced road leading to a cost analysis concluding that over a 26 year period a saving of at least 21% on maintenance costs has been achieved based on 2019 prices alone and is predicted to save more than 50% on overall costs.

The use of a Rotaflex inlay reinforced road represents a significant lifecycle cost saving.

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