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THE MITIGATION OF CONSTRUCTION NOISE ON THE CHANNEL TUNNEL PROJECT

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1. INTRODUCTION

The Channel Tunnel can be regarded as the biggest, most innovative and expensive engineering project to have taken place within Europe.

The scale of the works is overwhelming in terms of material requirements, manpower, duration, expenditure and design engineering. The contract programme spans over seven years, with a current total cost of almost £8 billion pounds. There has been a peak manpower requirement of 13,000 employees. The two terminals have a total area of 1,700 acres, there are 150kms of tunnel system and a vast network of Mechanical and Electrical works are ongoing.

To build such a complex transportation system, all major aspects of Civil Engineering has been employed to provide the infrastructure for the Mechanical and Electrical phase of the construction programme. The sheer scale of the operations can be shown in terms of the bulk fill importation and disposal of tunnel spoil. This required the use of fleets of heavy earthmoving plant including motor scrapers, towed scrapers, graders, articulated dump trucks and dozers on the Folkestone Terminal site and construction of a diaphragm sheet pile sea wall by driving some 22,000 interlocking steel piles continuously over a 3 year period.

Among the many likely impacts such a huge exercise would have on neighbouring residential areas, noise was an important aspect.

2. BACKGROUND

In order to protect local residents during construction, the Channel Tunnel Act of 1987 required that the works should be carried out in accordance with a Scheme of Operation approved by the appropriate Planning Authority. Among the matters the Scheme of Operation had to deal with were:

- the hours and days during which work was to be carried out.
- the suppression of noise and dust caused by any operations associated with the development.

2.1 Hours of Working

On Folkestone Terminal site, normal working hours are based on a maximum 12 hour day (0700-1900 hours) daily for six days a week. Only essential work could be carried out on Sundays such as plant maintenance.

Tunnelling is a continuous operation, 24 hours a day, everyday of the year, and to prepare for the main tunnelling operation an access shaft had to be initially sunk from the Shakespeare Cliff upper site. This was to be undertaken continuously 24 hours a day over a period of 4-5 months. However the remaining activities primarily to provide site facilities on the upper site were to be carried out on a 12 hours per day, 7 days per week basis. Except for the passage of tunnel workers (three shifts during the 24 hour working period, seven days per week) all other activities would be during the daytime only.

All works on the Shakespeare Cliff lower site were associated with the continuous tunnelling activity. However the majority of deliveries of materials by road transport would be limited, whenever possible, to the 12 hour period 0700 - 1900 hours. Delivery of tunnel lining segments was effected by using the British Rail main line running adjacent to the lower site and this activity was not curtailed by environmental considerations.

2.2 Noise Criteria

Based on the above working hours, general site noise criteria for construction activities taking into account the nature of the localities and the anticipated site activities were agreed and are shown in Table 1. The criteria were proposed at levels of site noise within which the contractors would generally operate unless essential work was absolutely necessary. If activities not of an emergency nature were to be

undertaken, then a separate application had to be made to the Local Planning Authority for a short term agreement to exceed these criteria. As part of the agreements, possible consultation with local residents was to be held and careful monitoring of the specific activity would take place in conjunction with local Environmental Health Officers.

It was made clear that the activities would not continuously cause noise levels at the criteria stated, but there would be long periods when noise would be at or below existing ambient noise levels in all areas. Of course, BS 5228: 1984 "Code of Practice for noise control on construction and open sites" was to be complied with, including noise control by best practicable means.

2.3 Initial Noise Control Measures Proposed

Prior to the construction activities initial noise control measures were considered appropriate as follows:

Folkestone Terminal

Provision of temporary earth mounds or fences to provide not only acoustic but visual screening to residential properties on the boundaries of the site.

Where noisy activities had to take place that would exceed the criteria, they would only be undertaken during the daytime and not at night.

Vehicular movements on site would be restricted to specified haul routes and speed limits.

Eurotunnel had identified that in certain areas adjacent to the Terminal, residential properties would be exposed to operational noise in excess of the proposed facade night time criteria of 50 dB LAeq (2200 hours - 0700 hours). As such, the client gave an assurance that these properties would be provided with noise insulation. The public and the contractor benefitted from the undertaking as ET decided to install this noise insulation early during the construction programme in 1988 as opposed to 1993.

Shakespeare Cliff

Formation of a 4m high earth bund close to the nearest residential area to provide protection to first floor windows.

Plant to be parked at west end of site to reduce intrusion from start up.

Silenced power generators to be used.

3. MITIGATION MEASURES

3.1 Complaints Procedure

It was appreciated that a project of this magnitude would give rise to complaints from the local residential community. To act as a focus for these, and to help resolve any justifiable areas of concern, an independent Channel Tunnel Complaints Commissioner was appointed to liaise if necessary, between the client Eurotunnel, the contractor TML, the local authority and the public. Within TML, the Environmental Engineer acted to liaise with site management, the complainant and the local authority Environmental Health Officer as an integral part of a Complaints administration procedure. From the outset, close liaison was maintained with the local authorities specialist Environmental Health Officer to ensure that statutory obligations were being met and also to show "best practicable means" were being employed.

3.2 Noise Monitoring

To show compliance with the noise criteria of the Scheme of Operation, routine long term noise monitoring was carried out at neighbouring residential properties. Preliminary estimations, using noise data contained in BS 5228, identified potentially noisy plant and operations which could have had an impact at properties closest to the area of work. Noise monitoring data would be collected and made available to interested parties. If necessary, the activity would be restricted in terms of hours of operation per day to ensure that day or night time maximum or LAeq noise levels were not exceeded.With operations such as pile driving which often gave rise to complaints because of the subjective and impulsive nature of the noise, monitoring would be carried out in conjunction with the local authority Environmental Health Officer so that they could be satisfied of compliance.

Where it became apparent that activities may indeed give the local authority cause for concern, the Environmental Engineer would liaise with site management to programme the works so that, for example, haul roads carrying heavy plant would be furthest away from noise sensitive properties. Such interfaces with site management would ensure that if challenged by the statutory authority, TML could ensure that all reasonably practicable steps had been taken to minimise the impact of the

particular operation.

3.3 Noise Testing

Another method used to ensure compliance with noise criteria was to noise test particular plant which would be brought in on a trial basis. Not only did this allow the engineers to assess whether the plant was fit for the purpose but we could also determine, with some accuracy, the nature of the noise and also the noise level. This exercise was used for various types of mobile piling equipment including those used to place the diaphragm sheet pile wall at Shakespeare Cliffe. In this instance, during the trial piling at sea level, noise measurements were undertaken on the cliff tops at Shakespeare Cliffe in order to select the appropriate rig to minimise disturbance at the nearby residential area of Aycliffe.

3.4 Acoustic Screening

During examination of hired plant, it has proved necessary to ask for additional silencers to be fitted to provide further noise control to exhaust noise, particularly from scrapers.

The formation of permanent structures such as earth bunds including those identified earlier in Section 2 were undertaken early on in the programme of works to provide noise screening to adjacent properties. However it was necessary to ensure that those members of the public who were to be temporarily affected by earthmoving plant were fully appraised of the works being carried out so that they would realise the longterm benefits of the work being undertaken.

3.5 Public Relations

There were many advantages to be gained in making the public aware of works taking place. Educating the public certainly helps to allay any fears they may hold about the duration of particular works and also they appreciate being advised, out of courtesy, about developments on their doorstep. To achieve this end and to promote the concept of the Channel Tunnel transportation system from an early stage, the client, Eurotunnel, opened an Exhibition Centre overlooking the terminal works in September 1988 to which the public have access. Once a year, the local community are invited to the Centre, free of charge, so that they can see for themselves the aims of the construction teams and also air any opinions or complaints regarding the impact of the works during construction and operation. As an additional opportunity for the public to be made more aware, these meetings were considered to be invaluable.

It soon became apparent that TML could appease complainants without the intervention of the local authority and as the public became familiar with the works, the number of complaints received regarding the established operations quickly reduced in number.

4. NATURE OF OPERATIONS

The nature of the complaints received from the public have been very varied and they broadly divide into two areas, those resulting from occasional, unpredictable events such as one off metal grinding operations and those more persistent longer term operations such the use of earthmoving plant or dredging ships. An analysis of all complaints since May 1988 is given in Table 2. The peaks due to complaints of noise were caused by the commencement of earthmoving on the terminal site in May 88 and the transportation of marine sand in October/November 1988. Problems associated with the latter are described later in Case Studies.

In some cases, the isolated short term noisy event is difficult to investigate because of the sheer scale of the works. Despite these events not exceeding those Lamax limits described earlier they are a subjective noise nuisance because of the very low background noise level that exists in some of our surrounding environs. It has been the case, because of critical activities and plant breakdowns, for workmen to repair defective equipment eg tunnel boring equipment, in order to ensure the safety and continuity of certain operations. In such cases, whilst these events are few and far between, unavoidable noise disturbance has resulted and the complainant is not usually satisfied with the company's response to the complaint, or the action taken by the local authority.

With longer term operations that are known to give rise to complaints, these people are visited by TML to provide the detailed information necessary to investigate the problem. The noise will be monitored and results will be shown to the local authority Environmental Health Officer so that it can be demonstrated that best practicable means have been used.

5. CASE STUDIES

In addition to bulk fill importation and disposal of tunnel spoil, other examples of inherently noisy operations have been temporary piling, transportation of marine sand, demolition of redundant bridges, rock breaking and pumping. Examples of two case studies are given below.

5.1 Shakespeare Cliff Access Shaft

The commencement of works at Shakespeare Cliff was marked by the 4-5 months continuous shaft sinking operations at the upper site. From the initial stage regular noise monitoring took place. This was necessary to show compliance with the criteria and also to act as an opportunity to have good relations with the Local Authority and the residents. It proved to be a worthwhile exercise since modifications were considered appropriate to the height of acoustic screening provided between the works and the residences and also partial screening to the motor at an elevated position of the main tower crane.

5.2 Transportation of Marine Sand

The operation involving the importation of marine sand fill to the UK Terminal via an overland pipeline from the coast at Hythe proved to be an interesting case. Planning permission for this operation was granted by the local authority once they were satisfied that the operation would not have an adverse impact on the local community. The dredging company backed up their proposals with a noise assessment which showed their was little cause for concern.

The sand fill operation worked to a 24 hour cycle, 7 days a week. The Trailer Suction Hopper Dredger extracted sand from the Goodwin Sands and commuted to Hythe where it connected with a booster ship to enable their combined pumps to transport the sand water mixture through a pipeline to lagoons on the UK Terminal. As the Trailer Dredger would complete a return journey in 7.5 hours, at least one discharge of sand would be made during nighttime hours. The two ships, anchored 600m off shore, had a combined pump power output in excess of 10,000 hp and all of this would be needed to lift the sand water mixture to an elevation of 60m along a pipeline some 4km long. In calm stable atmospheric conditions, complaints were received from a wide range of properties located along the adjacent coast. The very large slow revving diesel engines of the ships emitted very low frequency sound and whilst this would be barely audible above the background noise level in the vicinity of a complainant's property, the sound would be perceptible within certain rooms of a dwelling and indeed, vibration of windows and glass cabinets was alleged.

One-third octave frequency band analysis showed dominant sound pressure levels at 31.5 and 63 Hz and this correlated with the fundamental firing frequency of the engines. It was certainly not feasible to fit extremely large silencers to the ships and following a detailed noise analysis by a

noise consultant employed by the dredging company, it was shown to the local authority that despite the number of complaints received, the excess noise was not significantly over the background noise of 34 dBLA90 at night. The most critical method of assessment would be to use BS 4142, which deals specifically with fixed installations as distinct from temporary works. Even though BS4142 is not entirely relevant to the dredging operation, the rating level only exceeded the 34dBA background level by an amount suggested as being of marginal significance in the Standard.

As a gesture to those complainants who felt very strongly aggrieved by the pumping operation, the dredging company voluntarily offered to temporarily rehouse the household in a comparable rented property. This unconditional offer was made to two households, however the complainants declined to take advantage of this. Another household living on the coastal road had asked whether they could be provided with noise insulation to the facade of the house. They believed that the noise insulation package included thermal double glazing. They were advised of the different performances of the two types of glazing but this did not deter the occupiers from insisting upon thermal sealed unit double glazing. and the dredging company made a gratuitous payment to the household. Thermal glazing, was installed shortly afterwards and no further complaints were ever received.

It is worth highlighting that whilst the marine sand bulk fill operation had considerable programme and commercial benefits to the project, it also gave considerable environmental benefits such that if an equivalent volume of bulk fill had been imported by road, an estimated 500,000 lorry movements would have been necessary, from further afield sources of material.

6. CONCLUSION

The key to the management of the potential impact of the works upon the local community has been liaison with the public and statutory authorities by a specialist person within the company. As an advisor to the Project Management, they in turn must be aware of not only the statutory and moral obligations placed upon them but also the consequences of legal action. Noise monitoring is a key requisite to placate external parties but it must also be shown that thought has been applied to every potentially noisy activity. A willingness to work with the local authority with a comparable level of expertise helps to amicably resolve complaints. Indeed, the local authority, who are often caught in the middle between the aggrieved member of the public and the best practical means contractor, are often happy for the direct

involvement of the contractor's representative. It is also most valuable to the cause of the contractor for the public to be aware of the developing works and there is no doubt public awareness reduces the likelihood of any complaints being received.

TABLE 1 : GENERAL NOISE CRITERIA* FOR CONSTRUCTION

		Cheriton, Morehall & Folkestone Park (dB)	Saltwood, Folkestone North of M20 & South of the main Railway Line. (dB)	Dover dB
Monday - Friday (0700-1900) Saturday (0700-1400)	LAeq ***	67	62	65
	LAmax **	80	80	80
Monday - Friday (1900-2200) (1400-2200) Sunday & Public Holidays (0700-2200)	LAeq	57 (3 hour) or 62 (1 hour)	52 (3 hour) or 57 (1 hour)	55
	LAmax	70	70	70
Any night-time (2200-0700)	LAeq (1 hour)	47	47	45****
	LAmax	60	60	60

* All noise levels are site noise levels as defined in BS5228:1984 measured in the vicinity of an uninsulated property but not closer than 4m from a facade.

** The maximum levels to be measured on slow meter response.

*** LAeq to apply to full period unless noted otherwise.

**** At times other than shaft sinking.

TABLE 2 COMPLAINTS ANALYSIS

Analysis of all complaints received by TML (Shearway House) from members of the public directly, or indirectly via the Channel Tunnel Complaints Commissioner and Eurotunnel since 9/5/88.

		1989																		1990								
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
FOLK TERMINAL & Ashford	Noise	41	5	75	5	6	19	12	7	1	1	4	1	5	-	-	*1	*2	-	1	-	-	*1	*1	-	-
	Dust	2	3	4	3	-	2	-	-	1	-	5	2	7	1	7	*1	1	1	1	-	-	-	3	3	16
	Mud	2	2	1	1	5	6	7	-	5	4	1	-	-	-	1	-	-	1	-	-	-	-	-	-	-
	Lorries/Routes	2	8	1	1	4	6	3	1	3	4	-	1	-	1	1	-	-	1	-	*1	-	-	1	-	-
	Out of hours wkg.	1	1	2	4	1	2	1	2	1	1	-	-	5	1	1	-	*1	-	-	-	-	-	2	2	-
	Marine Sand	-	-	3	1	-	13	10	1	4	9	6	2	4	2	2	1	-	-	-	-	-	-	-	-	-
	Other	3	9	9	13	8	9	6	3	1	6	4	3	2	1	3	4	2	3	3	*2	2	5	3	2	2
HOLYWELL	Noise	-	1	-	-	-	-	3	2	-	1	-	3	1	-	-	-	-	-	-	-	-	-	1	-	-
	Dust	-	-	-	2	1	-	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-
	Mud	-	-	2	-	1	1	1	4	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Lorries/Routes	-	1	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Out of hours wkg.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Other	-	1	1	-	-	2	1	1	1	-	-	-	1	-	-	-	-	-	-	1	1	-	-	1	-	-
S. CLIFF inc. Farthinglow	Noise	-	2	1	1	-	1	2	1	2	-	-	1	1	-	-	2	1	-	-	-	-	-	-	-	-
	Mud	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Out of hours wkg.	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Other	-	1	2	-	2	-	-	1	1	-	-	1	-	-	1	1	-	-	-	1	-	2	-	-	-
	TOTAL	51	34	109	31	28	58	52	23	22	27	22	15	22	11	19	10	6	7	6	5	2	8	12	7	18

Note 1

"Other" - mainly one-off complaints such as bicycle/car accidents; stolen village seat; bad TML driving; BR train operations; silted polluted streams; loss of trade; dumped rubbish; smoke; men urinating; Biggins Wood; pot-holes; sick cats and increase in local rabbit population.

Note 2

Marine sand complaints include flooding and TV interference.

Note 3

Not included in the above figures are the claims in respect of alleged damage (eg windscreens, most of which are not TML's liability) which are passed on to the Commercial Department for investigation.

Note 4

A number of these complaints, between 10% and 20% according to month - 100 at 31/5/90, have been found to be unrelated to the activities of TML

Note 5

As at 31/5/89 there has been a total of 530 complaints made by 303 complainants.