BITUMEN COMPOUND SL
Slip Layer for bearing Piles and Buried Structures

Development of bitumen Compound SL

Bitumen Compound SL was developed in the 1960's for a dependable and economical counter-measure against the effects of negative skin friction on bearing piles. Increasing use of reclaimed land and filled sites for building and construction resulted in a much wider use of piled foundations, but introduced a hitherto little recognised phenomenon- negative skin friction.

Settlement of fill, or similar soil movement due to superimposed loadings, was found to be capable of increasing the effective loading on piles as much as 100% or more of their design capacity. The shell approach was to design a bitumen compound which, when applied at a suitable thickness, would shear within itself under the slow soil movements associated with ground settlement. In shearing, the compound must transmit only a negligible proportion of the "donwndrag" to the pile or other supporting surface.

Although this was the primary aim, a number of other criteria had to be met to produce a practical and technically suitable material for general site use. These included:

a) The coating must be applicable on site with a minimum of equipment.
b) It should resist flow ag ambient temperatures for long enough to install the piling without significant sagging of the coating.
c) The coating should resist detachment when piles are hammered.
d) The coating should not shear off the pile during driving through soil of the nature expected to cause negative skin friction.
e) It must resist possible upward flow due to horizontal soil pressure.
f) The coating must resist significant penetration of coarse angular soil particles after driving.
g) It must not reduce the effective soil support needed to prevent buckling of a pile.

After considerable research and trials, a compound was developed which conformed sufficiently closely to the range of requirements to be acceptable from both the practical and technical points of view.

Shell showed their confidence in the compound by incorporating it in the foundations of the new Shell Nederland Chemie Plant at Moerdijk in Holland where some 9000 precast concrete piles of 15-19m length were coated with the compound, now known in the U.K as BITUMEN COMPOUND SL- its first large-scale use. Since then, BITUMEN COMPOUNS SL has been used internationally for many projects- primarily as a slip layer on piling but also for other buried structures where loadings due to soil movement must be effectively eliminated. A list giving brief details of many of these projects is available on request.

How it functions

BITUNMEN COMPOUND SL is a hot-melt bituminous compound which does not contain solvents. It is applied hot to pile surfaces and piles can be driven as soon as the compound has cooled to ambient temperature.

The material has visco-elastic properties. As a result, it acts like a hard rubber under the short loading times of piling hammer blows. This property enables it to be driven through a variety of soils without significant damage to, or stripping of the coating so that the full thickness remains intact throughout installation of the pile.

Once in position and when subjected to the much slower loadings resulting from consolidating or moving soil, the product assumes fluid properties and shears within itself. It is this viscous shearing action which all but eliminates load transmission through the coating, caused by relative movements between its two surfaces.

It is pointed out however, that use of BITUMEN COMPOUND SL in now way reduces the friction occurring between soil and pile ***during*** driving. It functions purely by shearing within itself after the pile has been installed.

A summary of Shell's research into this subject can be made available to interested parties.

Although primarily intended for precast or other driven piling, BITUMEN COMPOUND SL is equally suitable for in-situ piling where application is feasible.

Two grades are available-standard and tropical-covering most conditions except extreme heat and extreme cold.

How effective is it?

A later section deals with calculation of loading transmitted through a layer of BITUMEN COMPOUND SL. As a guide, however, the reduction of downdrag load due to negative skin friction or other soil movement when using an appropriate thickness would exceed 90%.

Downdrag loadings on uncoated surfaces due to soil movement are difficult if not impossible to predict with accuracy and these can in practise considerably exceed the anticipated value. By using BITUMEN COMPOUND SL as a slip layer, the effect of any excess loadings is largely eliminated as the coating would transmit only a small percentage of any extra load. In this way, it constitutes a valuable "Insurance Policy" against the potentially serious effects of loadings beyond the design limits of the piling.

Practical post-installation evidence of the effectiveness of BITUMEN COMPOUND SL is contained in a report on

the instrumented performance of coated piles supporting a road bridge abutment at Newhaven, Sussex. Details are given in CIRIA technical Note No 109 and a summary of the relevant part is available from LAYBOND PRODUCTS on request.

Uses

Typical conditions where the use of BITUMEN COMPIUND SL can prove highly effective include:

- *Piling subject to negative skin friction and superimposed soil loadings.*
- *Prevention of structural load transfer from piling to adjacent sensitive underground structures (e.g rail tunnels).*
- *Prevention of frictional loading on buried surfaces e.g basements, tunnels, old foundations and sheet piling.*
- *"Clay-heave" situations in piled building foundations.*

And many more where relative movement between soil and buried surfaces can cause unacceptable additional loading.

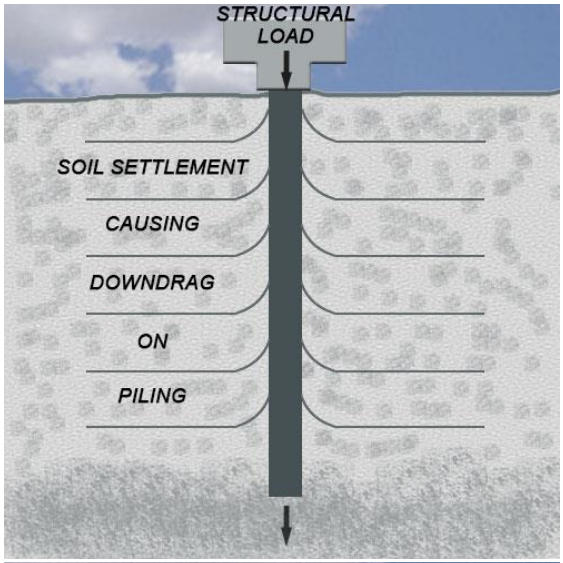
Load transmission through BITUMEN COMPOUND SL

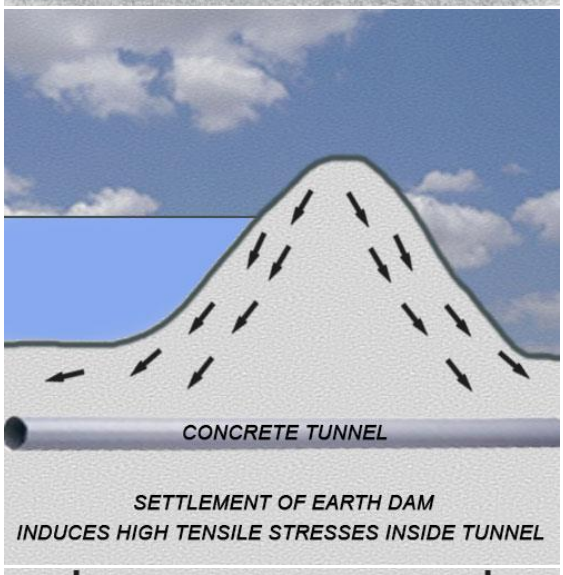
Where a pile or other structure is to be coated with BITUMEN COMPOUND SL, the frictional drag caused by moving soil, transmitted through the coating is a function of:

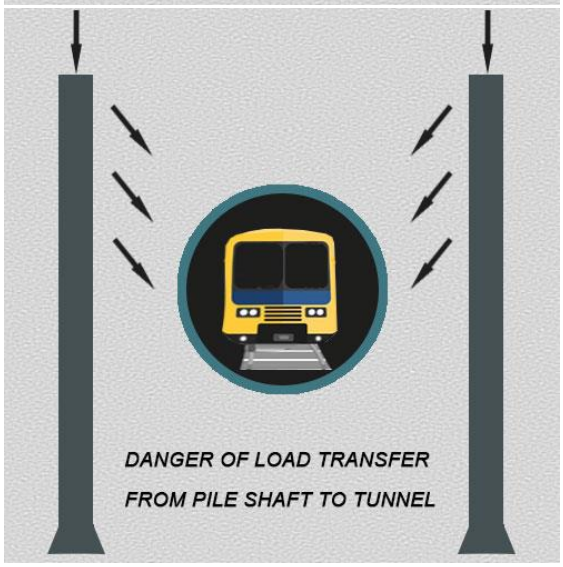
1. Temperature of coating (i.e soil temperature)
2. Expected rate of settlement or movement of soil.
3. Thickness of coating.
4. Flow characteristics of the coating under load.

Items 1,2 and 3 are generally relatively easily obtained or assumed. Item 4 is more complex and involves detailed knowledge of the behaviour of the Compound under different conditions.

However, in order to avoid complicated calculations for every individual situation, a range of constants (K) which take into account the flow characteristics of the coating, have been calculated. These, when incorporated into the appropriate formula, enable a close approximation of the downdrag or other type of loading transmitted through a coating of BITUMEN COMPOUND SL, to be obtained.
In devising the formula, it has been assumed that there is 100% bond between the soil and the coating and between the coating and the surface to which it is applied. This is the worst situation and anything less than 100% bond at both faces will result in a reduced *load transmission from the moving soil through the* coating to the structure.







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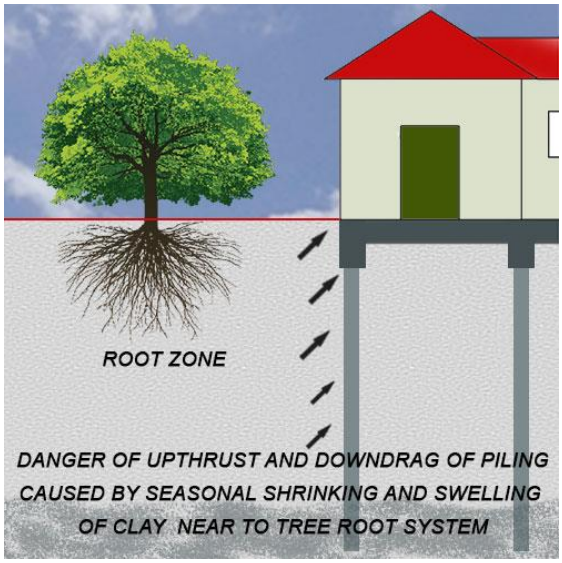

Formula

Stress transmitted through a coating of BITUMEN COMPOUND SL

$$= K \times \frac{\text{Anticipated rate of ground settlement or movement (mm/year)}}{\text{Coating thickness (mm)}} \text{ N/m2 of surface area}$$

To obtain the total load transmitted, the resultant figure is multiplied by the surface area over which the soil movement is expected.

Please note that although eh settlement (or movement) is expressed in terms of mm/year, this may not be the amount of settlement occurring over the 12 months. If for example, most of the settlement were expected in the first 6 months, amounting to say 100mm, this would be entered into the formula as 200mm/year i.e the rate of settlement expressed in terms of mm/year.

Values for constant K

These are related to the temperature of the coating i.e the anticipated soil temperature. Soil temperatures in the U.K are generally of the order of 10°C. However, the tables below provide K values for a range of soil temperatures applicable to the Standard and Tropical grades of BITUMEN COMPOUND SL.

As far as coating thickness is concerned, for maximum security (resistance to mechanical damage, resistance to long-term penetration of soil particles, application error etc) 10 mm can be considered. However, according to the degree of ground settlement, constituents of the soil, anticipated duration of settlement and other factors, this can be reduced but should never be less than 3mm. generally, a thickness of 6mm is regarded as a suitable optimum

TABLE A

BITUMEN COMPOUND SL (Standard Grade)

Average soil Temperature °C	5	6	8	10	12	14	16	18	20
K Value	16.8	13.4	8.4	5.0	3.0	1.7	0.95	0.5	0.33

TABLE B

BITUMEN COMPOUND SL (Tropical Grade)

Average soil Temperature °C	12	14	16	18	20	22	24	26	28
K Value	436	234	140	86	56	40	25	17	10

Example of calculation

Using the Standard grade of BITUMEN COMPOUND SL on end -bearing piles in a region where the average soil temperature id 10°C and where a rate of ground settlement of 250mm/year is anticipated:

From table A, K for 10°C=5.0

A coating thickness of 6mm is assumed.

The downdrag stress transmitted through the coating is therefore:

$$\frac{5.0 \times 250}{6} = 208 \text{N/m2}$$

If the surface area of the pile subject to soil movement were, say, 25m2, the total downdrag load on the coated pile would be 25x208= 5.2kN

It is suggested that a factor of safety of 2 is used to take care of temperature and other variations so in the above example a total downdrag load of say 10kN would represent a safe working figure. This, in practical terms would be considered negligible.

The downdrag load on uncoated piles is difficult to predict accurately, but in general, the reduction in downdrag loading by using an appropriate thickness of BITUMEN COMPOUND SL would exceed 90%.

Test-loading of coated piles

Where piles which have been coated with BITUMEN COMPOUND SL are to be test-loaded, the following points should be borne in mind:

1. This should always be done in comparison with an identical uncoated pile installed to the same depth and in the same soil location as the coated one. The two piles should however,

be far enough apart for there to be no loading influence between them.

2. The coated pile should be in the ground for a long enough time to allow the temperature of the coating to stabilise with the ground temperature, before loading. This is especially important where test piles are constructed in-situ, the coating having been pre-applied to a permanent casing. Heat created by hydration of the cement during setting can raise the temperature of the coating well above that of the soil. If test-loading is carried out before the coating temperature has reverted to the soil temperature, the results are likely to be of little value unless the actual coating temperatures can be measured.
3. The formula for calculating the anticipated rate of pile settlement under loading should be regarded as a guide to performance rather than a n accurate prediction. This is because-
   A. Of necessity loading is carried out over a relatively short time and the relationship between load transmitted and the time during which it is transmitted is not necessarily straight-line.
   B. Relatively small variations in coating temperature can have a significant effect on load transmitted (see Tables A and B). Although when performing in service any total load variation from this cause is likely still to be negligible, it can be wrongly interpreted when measuring actual values recorded during short term loading tests. These cannot of course correspond to the conditions to which piling will be subjected in service.
   C. It is virtually impossible to ensure a precise and uniform coating thickness. As the load transmitted through the coating is directly proportional to its thickness, any variations in uniformity and /or thickness are likely to reflect in the test results.

Other structures

Many other situations occur where relative movement between soil and structure creates excessive loadings. In the majority of cases, these loadings can be virtually eliminated by the use of a slip layer of BIUTMEN COMPOUND SL. Stress transmission calculations are made according to the formula previously indicated.

Suitable piling systems

BITUMEN COMPOUND SL can be used with most piling systems either as they are pr with appropriate modifications.

As a hot-melt compound which solidifies by cooling, it has to be pre-applied before piling is installed. This can be carried out on such piles as:

- Precast concrete (including “shell” piles)
- H-section steel piles
- Circular steel casings
- Steel sheet piling

And is usually applied on site.

It cannot be used on continuous flight auger or similar in-situ piling unless some form of precoated liner can be installed in the shaft prior to concreting. Such a liner need only be substantial enough to support the coating until concreting has been completed.

In-situ vertical surfaces

BITUMEN COMPOUND SL has been successfully applied to in-situ vertical surfaces such as concrete walls and columns and on brick walls and piers (e.g to isolate them from externally superimposed loadings).

A practical technique has been established for this which consists of “casting” panels of BITUMEN COMPOUND SL onto kraft paper then applying them while still warm to the primed surface. Details are available on request.

Installation through hard ground

In most cases, BITUMEN COMPOUND SL is required to be installed through relatively soft, compressible soils which are the ones most likely to create negative skin friction. In some cases, however, the coated piling has to be installed through denser layers of sand/gravel due to the characteristics of the strata concerned.

Firmly adhered BITUMEN COMPOUND SL provides a tough abrasion- resistant coating under hammer-blow loading times and when driven through sand of medium density should suffer little damage except at the leading edges.

The denser the sand or the harder the ground, the greater is the possibility of damage to the coating and where doubt exists, it is safer to drive test piles and /or consider alternative methods of installing the piles. The latter might for example consist of preboring using C.F.A rig and injecting bentonite slurry instead of grout to maintain the bore. The coated piles are then installed through the slurry.

Whatever the conditions, however, where coated piles have to be driven, the most important requirement is that the BITUMEN COMPOUND SL is ***firmly*** bonded to the pile surface. It is always wise to test the adhesion before driving the pile.

Typical technical data

BITUMEN COMPOUND SL	STANDARD	TROPICAL

BITUMEN COMPOUND SL

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Colour	Black	Black
Method of application	By heating and pouring	
Max. heating temp (°C)	180	190
Typical application temp (°C)	150	160
Product weight	1000kg/m3	
Coverage	1KG/M2 per mm thickness (and pro rata)	
Flashpoint in container (°C) (Cleveland Open Cup)	250	250
Storage Life	Indefinite	Indefinite

Container sizes

Standard Grade:	25kg Easy-strip cartons
Tropical Grade:	155kg light gauge steel drums

Typical Specification for application of BITUMEN COMPOUND SL for inclusion in a Bill of Quantities.

a) The length of pile to be coated shall be ___ extending from ___point to point___

b) Steel surfaces should be cleaned free of any loose rust and scale. Concrete must have curved sufficiently to achieve its required strength and should be clean and free from laitance. Surfaces to be treated must be dry.

c) Where priming is required. A priming coat of bitumen primer is to be applied by brush or spray at about 0.2litres/m2. The priming coat must be dry before the BITUMEN COMPOUND SL is applied.

d) The slip layer shall consist of BITUMEN COMPOUND SL manufactured by Consolidated Coating Ltd, Kaymar House, Budby Road, Cuckney. It shall be heated gently at a temperature not exceeding 180°C until melted, without any localised overheating. It shall be applied by pouring or spreading by trowel or squeegee or by casting in, moulds or by a combination of these methods, whichever is most appropriate to the circumstances. Rotation of circular piles my assist in even distribution.
More than one coat may be required to achieve the necessary thickness. Checks will be made by the Engineer on the thickness of the completed coating which shall be a minimum of ___mm.

e) Piles should be driven as soon as possible after the coating has cooled to ambient temperature to avoid sagging during prolonged storage of coated piles.

f) If coating has to be carried out in wet or other weather conditions which may adversely affect adhesion of the slip layer or primer, a weather-proof cover shall be erected over the appropriate length of pile during coating. Certain precautions may need to be taken for hot or cold weather working or transporting coated piles and the recommendations of Consolidated Coatings Ltd should be followed where appropriate.

Application Guide

A separate guide to application methods/techniques is available on request.

Technical Advice

This is available from our contact page or consolidatecoatings@gmail.com

Mobile: 07557 505 114