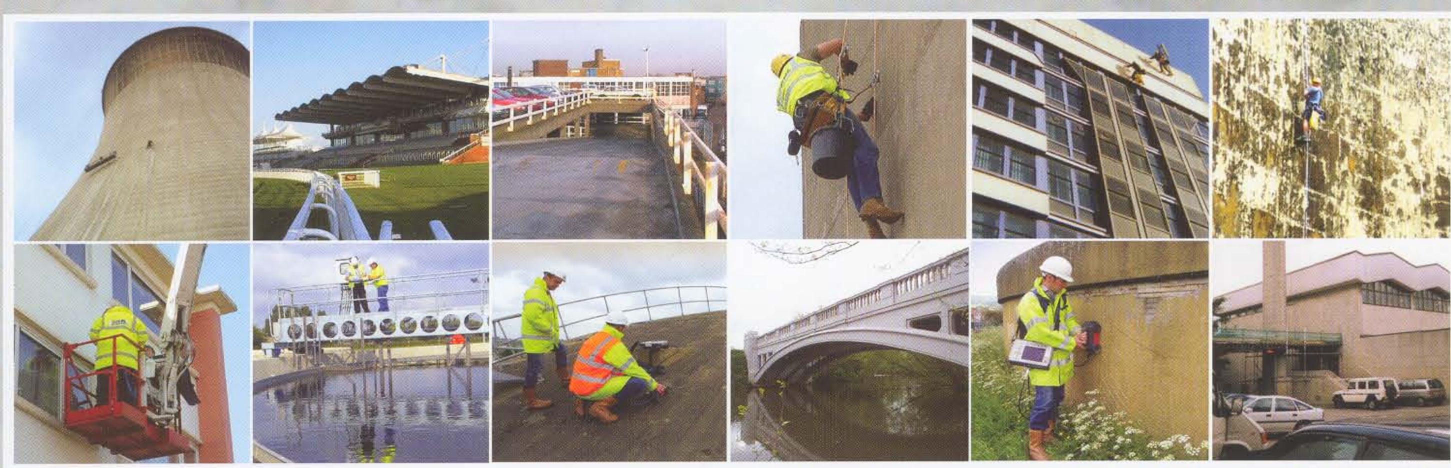
CONDITION ASSESSMENT
OF
ROBIN HOOD'S BAY SEA WALL
FOR
SCARBOROUGH BOROUGH COUNCIL



CRL SURVEYS
Structural and building assessment

CONDITION ASSESSMENT
OF
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FOR
SCARBOROUGH BOROUGH COUNCIL

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CONTRACT DETAILS

Contract No.:	SUR07605
Site:	Sea Wall, Robin Hood's Bay
Client:	Scarborough Borough Council Technical Services Town Hall St. Nicolas Street Scarborough North Yorkshire YO11 2HG **For the attention of: Mr. Martin Lloyd**

FOR CONCRETE REPAIRS LIMITED

Authors:	Simon Bladon BSc., MSc. Survey Division Manager Grzegorz Nowakowski Survey Division Area Manager (UK North)	**Approved:**	Simon Bladon BSc., MSc. Survey Division Manager
		Signed:	[signature]

REPORT DETAILS

		Issue and Revision		
This Report Comprises:	32pages of text Appendix A Appendix B Appendix C Appendix D	**Date**	**Rev**	**Description**
		13th July 2007 17th July 2007	 1	Draft for Comment Final

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CONTENTS

1. INTRODUCTION

1.1 References

CRL Surveys letter Ref: SUR6060622/SB/sb from Simon Bladon of CRL Surveys to Mr. Martin Lloyd of Scarborough Borough Council, dated 22nd March 2007

Site meeting between Mr. Martin Lloyd of Scarborough Borough Council, Mr. John Lea of Fosroc Limited and Messrs Simon Bladon and Grzegorz Nowakowski of CRL Surveys on 15th May 2007

CRL Surveys letter Ref: SUR6060622/2/SB/sb from Simon Bladon of CRL Surveys to Mr. Martin Lloyd of Scarborough Borough Council, dated 17th May 2007

Email from Mr. Martin Lloyd of Scarborough Borough Council to Simon Bladon of CRL Surveys on 25th May 2007

CRL Surveys acknowledgement and acceptance of instructions, letter Ref: SUR60622/SUR07605/SB/sb from Simon Bladon of CRL Surveys to Mr. Martin Lloyd of Scarborough Borough Council, dated 26th May 2007

1.2 General Background

Concrete Repairs Limited (CRL Surveys) were asked by Mr. Martin Lloyd of Scarborough Borough Council to carry out a condition survey of The Sea Wall at Robin Hood's Bay.

We were particularly asked to augment the survey and investigation works previously carried out by others (footnote 1) in order to clarify the nature of and log the evident defects so that the extent of remedial works could be evaluated.

Our Engineers attended site during the period 18th May 2007 to 20th May 2007 and their findings are detailed as follows.

[1] Middlesborough Council Laboratory Services carried out a condition survey during 2006. A copy of their Report, No. 06/148 was submitted to us and a copy has been included here as **Appendix A**, for ease of reference.

2. GENERAL SITE DETAILS

From the drawings submitted, the structure was built during the early 1970's and formed using a series of pre-cast, reinforced concrete units, fixed back to the cliff face with rock anchors, with the gap between the back of the pre-cast wall and the cliff face backfilled with mass concrete encapsulating a drainage system.

General viws of the wall have been prepared as Plates T1 to T4 below:

Plate T1: General view of the wall from the northern end.

A

B

Plates T2: General views of the sea wall from the southern end

Plate T3: Close-up of the wall showing pre-cast columns, separated by discrete panels. Rust staining was widespread.

A

B

Plates T4: Views at the top of the wall, showing a small parapet, with handrail and paved walkway of extremely variable width.

3. CONDITION ASSESSMENT - PROCEDURES

3.1 DEFECTS AND DILAPIDATION'S

3.1.1 Visual Inspection

The wall was be subjected to a full close-quarters visual inspection.

All defects and dilapidation's identified were uniquely referenced, the references recorded onto drawings and then cross-referenced to a dilapidation's schedule, describing / classifying each defect / dilapidation and detailing, where appropriate, the approximate defect dimensions.

> **NB:** Defect dimensions are, however, given for guidance purposes only and should not be used in isolation for costing purposes.
>
> For example, the processes involved in concrete patch-repair include the preparation of some defects by cutting-out. Cutting-out is undertaken to both prepare the defects to accommodate repair materials and also to ensure that all of the defective concrete is removed and all deteriorated reinforcement is treated. Concrete patch-repairs could, therefore, be significantly different in both size and shape when compared to the defects from which they were derived. Limited exploratory cutting-out may be carried out, on some 'typical' defects in order to evaluate potential over-cut, defect to repair, but we would, nevertheless, point out that the only truly and fully accurate measure of repair quantities is that carried out once all defects have been cut-out, ready for repair.
>
> Furthermore, some defects identified by our technicians maybe considered by others as insignificant and / or not in need of repair and the defects / dilapidation's schedule/s produced should be carefully evaluated, by the Client, or his / her representative, or feedback provided, following the provision of our Report, if budget quotations for remedial works are required.

3.1.2 Hammer Testing and 'Make-safe'

3.1.2.1 Method

Suspect general areas would have been identified during the visual inspection works described above. The concrete surfaces were, however, as far as practicable, additionally subjected fully to light sounding using a "lump hammer". The hammer was drawn over the concrete surfaces or used lightly to tap the concrete in order to identify loose, hollow, delaminated and/or spalling areas (including latent or incipient spalling).

3.1.2.2 Removal of Loose Material

All areas of concrete and other materials considered to be loose and at risk of falling, safety permitting, were carefully removed. Any items considered to be at risk of falling, but not safely removable at the time of the assessment were identified to the appropriate authorities as soon as practicable.

These works, in our opinion, have 'made-safe' the elevations from the immanent risk of falling debris. However, until the processes of deterioration, as diagnosed below, have been arrested, by appropriate repair and maintenance, deterioration will continue and further loose material will develop. Therefore, the elevations investigated should be considered only to be temporarily 'safe' and will require regular and thorough monitoring. The frequency of such monitoring, and in particular the requirement for repeat 'make-safe' works will be dependant upon a number of factors, including the overall condition of the elevations and the level of deterioration, the processes of deterioration involved, the environment of exposure and context, e.g. the potential consequences of any falling debris. In our experience, periodic monitoring and / or 'make-safe's could be required at intervals ranging from weekly to annually, or even biannually.

We would also point out that although we have removed distressed material, and can predict that further deterioration will take place at these locations, we cannot predict, with any degree of surety, if, or where, distress may develop in the future, in currently sound or unblemished locations.

3.2 ASSESSMENT OF REPAIRS

The reinforcement within selected sound areas, at progressively greater depths of cover were exposed and inspected for evidence of deterioration and corrosion in order to assess the likely depth at which the reinforcement is potentially at risk from deterioration and corrosion.

In addition, the reinforcement at selected, representative existing spalled locations was chased back into sound concrete. Exposed and corroded reinforcement was further exposed in order to assess both the extent of corrosion, in relation to the depth of carbonation and depth of chloride contamination at that location, but also to determine reinforcement bar type/s, which would be identified using the classifications described within CIRIA Special Publication 118 (footnote 2). Reinforcement bar diameters and, if applicable, any loss of cross-section was recorded.

In addition, for guidance, the relative dimensions and form, of potential repairs, compared to the visual defects, were assessed, to provide, as far as practicable, data for the subsequent preparation of concrete repair bills of quantity, as described within the Concrete Repair Association (CRA), Standard Method of Measurement (footnote 3) and Concrete Society Technical Report No.38 (footnote 4).

3.3 MAKING-GOOD

All sampling holes and areas of intrusive investigations into the various elements were 'made-good' using proprietary repair materials and best possible practice.

The intrusions into the structural fabric were limited, both in number and size, our intensions to maximize the amount of information gathered, whilst minimizing the amount of disruption and damage caused. However, notwithstanding, such intrusions will now represent potentially 'vulnerable-points', until the structure has been subjected to appropriate repair and maintenance. We would particularly point out that making good to the concrete elements did not include the provision of any corrosion control measures and even with the proportions of chloride determined above, there will be, at least in some locations, a potential for the development of incipient anode corrosion.

It should also be noted that we have not re-decorated or reinstated any especially finished surfaces and weatherproofing details, where disturbed, although reinstated, were only 'made-good' as a temporary measure.

Future monitoring of the structure, especially if repairs and maintenance are not to be undertaken in the foreseeable future, should pay particular attention to the locations where sampling and intrusive investigations were carried out. Any failures at these locations should be rectified without delay.

[2] CIRIA Special Publication 118, 1995, "Steel Reinforcement".
[3] Concrete Repair Association, "Standard Method of Measurement for Concrete Repair".
[4] Concrete Society Technical Report No.38, "Patch Repair of Reinforced Concrete – subject to reinforcement corrosion. Model Specification and Method of Measurement".

4. CONDITION ASSESSMENT – RESULTS

4.1 'MAKE-SAFE'

These works, in our opinion, have 'made-safe' the east side of the wall from immanent risk of falling debris. However, until the processes of deterioration, as diagnosed below, are arrested by appropriate repair and maintenance, deterioration will continue and further loose material will develop. Therefore, the east side of the wall investigated should only be considered to be temporarily 'safe' and will require regular and thorough monitoring.

4.2 GENERAL

The detailed results have been prepared as Appendices, as follows:

Description	Appendix
Record Drawings	**B**
Defects Schedule	**C**
Exploratory Cutting out and Reinforcement Inspection	**D**

4.3 DEFECTS AND DILAPIDATION'S

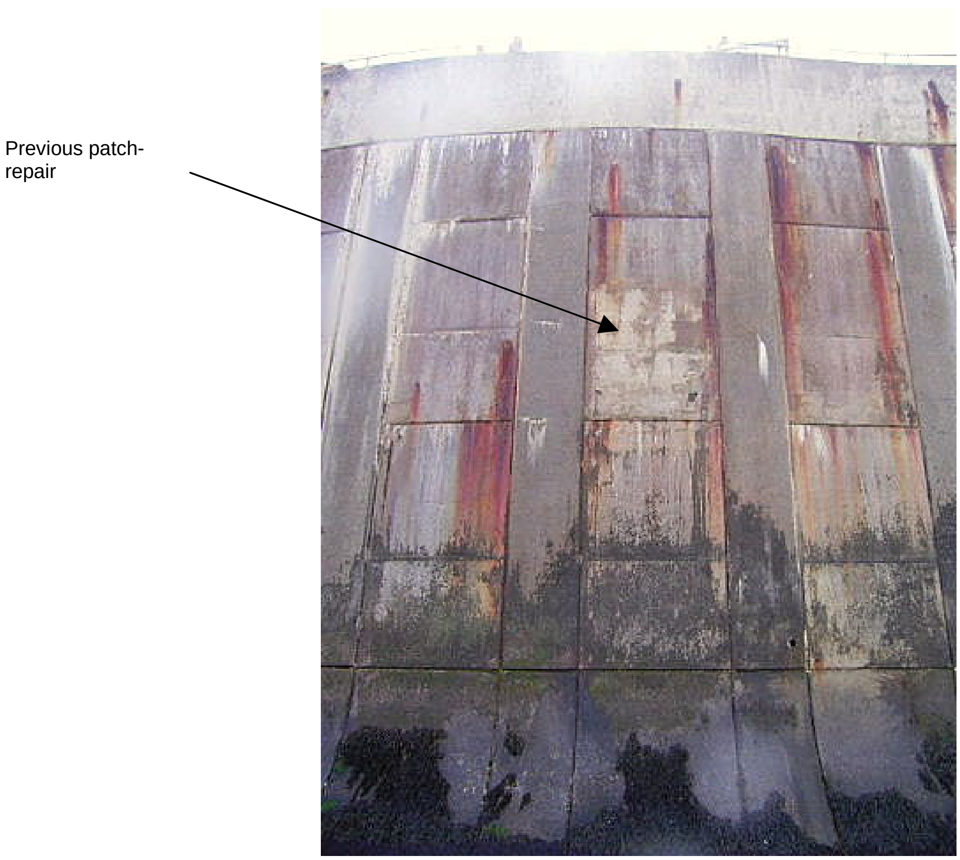

Plate T5: General view of Panels 29, 30 and 31 showing various types of 'defect' i.e. cracking, previous patch-repair, rust stains and white deposits.

Plate T6: Close-up of a typical rust stain, with associated surface spalling at the corner of a panel.

Plate T7: Close-up of previous patch-repair. Many were found to be hollow and delaminated.

Plate T8: General rust staining and spalling (arrowed) on the inside of the parapet wall.

4.4 ASSESSMENT OF REPAIRS

The rust stains were found to have derived from two sources, namely corroded reinforcement and degraded pyritous aggregate particles. As a very general rule, cracking and rust staining, mainly present along unit edges, represented the former, with isolated rust 'spots' generally representing the latter.

Exploratory cutting out revealed, in the limited areas investigated, that the sizes of defects comprising cracked and spalled concrete, resulting from corrosion of the reinforcement, would almost certainly increase significantly during preparatory works. In our opinion, in many areas, defects comprising discrete bars will probably become large-area repairs, to groups of bars.

Repairs to degraded pyritous aggregate particles, in our opinion, would generally be small, shallow patches, of similar dimensions, i.e. within the same category, to the defects recorded.

In many cases, the previous repairs identified were variably hollow and delaminated. A repair was partially broken out, revealing that corrosion of the encapsulated reinforcement, presumably the original reason for repair, was continuing. Furthermore, steel mesh reinforcement, placed in the repair was also starting to corrode. In our opinion, on the basis of the repair investigated, the materials used were not fit-for-purpose, probably not proprietary repair products and almost certainly not placed to a reasonable, industry, standard.

In areas were the reinforcement was exposed it comprised plain mild-steel.

5. DISCUSSION OF FINDINGS

5.1 CURRENT CONDITION

5.1.1 Appearance

The sea wall was obviously found visually to have deteriorated and exhibited distress in many areas.

The exposed surfaces were found to be variably weathered, discoloured and eroded, the latter particularly within the 'splash-zone', but generally consistent with concrete elements cast and exposed in this environment for approaching 40years.

However, the structure additionally exhibited widespread evidence of rust staining, cracking and surface spalling associated with corrosion of the encapsulated reinforcement, together with rust staining derived from the degradation of reactive pyritous aggregate particles and additional, possibly age / movement related cracking. In some cases the latter exhibited evidence of water seepage from behind.

In our opinion, this latter distress should be addressed and the processes of deterioration arrested as soon as possible.

5.1.2 Diagnostic Investigations

5.1.2.1 Background Discussion – The Deterioration of Reinforced Concrete

Experience has shown that in the vast majority of cases concrete deterioration in the UK over the last 50 years has primarily involved corrosion of the reinforcement and consequent spalling and delamination of the concrete surfaces. In most cases, distress has initially been non-structural and essentially surficial, which generally only effected appearances, although the spalling surfaces have represent a potentially significant Health and Safety risk, in terms of falling debris. If the deterioration has been allowed to continue, however, structural distress has developed, either within specific elements, or structures as a whole. The following paragraphs give a very brief summary of the typical processes of deterioration involved and are intended to aid the lay-reader to understand the reasoning behind the programme of investigations carried out.

> Reinforced concrete is a composite material generally comprising coarse and fine aggregates set in a cementitious matrix and reinforced with mild steel bars or rods. The cementitious matrix, generally a type of Portland cement is highly alkaline (pH values of fresh concrete in the range 12 to 13) which reacts with the steel surfaces to produce a passivating layer or film surrounding the reinforcement. Whilst the alkalinity of the concrete matrix remains high the passive film remains intact and deleterious corrosion of the reinforcement is unlikely, under normal circumstances.
>
> Once exposed to the atmosphere, which is essentially acidic the alkalinity of the concrete is neutralised, inwards from the exposed surfaces. The carbon dioxide in the atmosphere reacts with the alkali hydroxides within the concrete matrix to produce various carbonate compounds (and a reduction in pH to around 8 to 10), hence the term carbonation. Once carbonation has extended into the concrete to the level of the reinforcement the pH around the steel reduces and the passive film subsequently deteriorates. Potentially deleterious corrosion of the reinforcement can then occur.
>
> Building Research Establishment (BRE) Digest 444: 2000 (footnote 5) gives the following empirical formula for the "parabolic ingress rate" of carbonation:

$$d = k\,t^{n}$$

[5] Building Research Establishment (BRE) Digest 444, "Corrosion of Steel in Concrete", February 2000.
Part 1: "Durability of reinforced concrete structures"
Part 2: "Investigation and assessment"
Part 3: "Protection and remediation"
NB: BRE Digest 444 replaced BRE Digests 263, 264 and 265.

Where d = the carbonation depth,
k = a constant,
t = time,
n = an exponent lower than 1, often taken as 0.5

The rate constant, k, depends on a number of factors including:

cement type and content;
water:cement ratio;
aggregate type;
duration, relative humidity and temperature during a controlled curing period;
degree of compaction;
environmental conditions including relative humidity, temperature and the local concentration of carbon dioxide.

Generally, for average Portland cement concrete exposed externally, carbonation depths of between 3mm and 6mm would be expected at 5years of age, increasing to between 5mm and 8mm at 10years and between 10mm and 15mm at 50years. For the same concrete exposed internally values would be expected to be significantly higher due to drier exposure conditions and potentially higher concentrations of CO_2 in the atmosphere. (footnote 6)

Under normal circumstances whilst the pH level of the concrete matrix around the steel remains high, corrosion of the reinforcement is unlikely. However, in a concrete containing excessive chloride, present either as an original mix constituent (e.g. calcium chloride added as an accelerator or salt contamination of the aggregates or the use of saline rather than fresh mixing water) or as a subsequent contaminant from an external source (e.g. de-icing salts or sea water, both via either airborne spray or direct contact) severe and localised corrosion of the steel can occur regardless of carbonation.

Chloride contamination has the added complication that provenance and cement type can both significantly effect the amount of chloride available for deleterious reaction with the steel. The chemical analysis generally carried out indicates total (acid soluble) chloride and cannot differentiate between 'combined' (present as an intrinsic matrix or aggregate constituent) or 'free' (freely available for deleterious reactions) chloride. For example, in the case of chloride present at mixing, whether by deliberate addition, saline mix water or contaminated aggregates, a proportion of the chloride could become combined within the hydrated cement phases and therefore not freely available for corrosion reactions, until the matrix becomes altered, e.g. through the processes of carbonation.

BRE Digest 444: Part 2: 2000 indicates a 'Negligible' risk of chloride induced corrosion, in dry uncarbonated concrete, where values for chloride ion by weight of cement are less than SAY 0.2% for ingressed chloride and less than SAY 0.4% for original contaminants present at the time of mixing. The risk category significantly worsens in the case of the latter where the concrete is damp (in the case of ingressed chloride the concrete is presumably damp, at least intermittently) and, for both cases where the carbonation front has encroached upon the reinforcement. Carbonation can both reduce the threshold level for corrosion initiation and increase the probability of corrosion for a particular chloride concentration by reducing the pH and the chloride binding capacity of the cement paste.

The assessment of chloride provenance can be aided by the preparation and analysis of incremental depth rather than bulk samples. Concrete samples (most commonly drilled dust samples) carefully prepared to include material from selected depths beneath an exposed surface (SAY for example A: 5mm to 25mm (footnote 7); B: 25mm to 50mm; C: 50mm to 75mm; etc.) can be analysed separately to identify any variations with depth. A consistent decrease in chloride with depth from the surfaces

[6] Values obtained from BRE Information Paper (IP) 6/81, "Carbonation of concrete made with dense natural aggregates", April 1981 and BRE Digest 405, "Carbonation of concrete and its effects on durability", May 1995.
[7] The concrete within the outermost 5mm could be weathered and therefore not representative. This material is, in most cases discarded.

would be suggestive of chloride ingress from an external source after setting and hardening of the concrete. The analysis of samples from sheltered locations, away from any likely sources of external contamination (e.g. beneath asphalt toppings, above splash/spray zones and on leeward elevations) could indicate whether or not the concrete was likely to have contained any chloride at the time of mixing and casting. Incremental depth sampling would also enable a comparison between chloride contamination and the depth of cover to reinforcement, i.e. has chloride contamination from an external source extended inwards to the depth of reinforcement?

For the above reasons the concrete under investigation has been tested in-situ for depths of carbonation and depths of cover to the reinforcement together with laboratory analyses of samples for the contents of chloride.

In some cases, e.g. road, bridge and car park decks together with associated elements can be subjected to further testing as follows:

The corrosion of steel in concrete is an electrochemical process. The reinforcement generally exhibits cathodic (positive) and anodic (negative) areas, with the anodic portions potentially deleteriously corroding to cause the classic symptoms of surface delamination and spalling etc. In some instances the measurement of parameters including electrical potential (1/2 cell potential and corrosion rate measurements), electrical resistance and resistivity of the surface concrete can be used for the identification and evaluation of corrosion condition. Measurements taken at regular intervals, in a grid pattern across the surface of a concrete element can be used to identify relatively anodic and cathodic areas within the reinforcement and areas of concrete more, or less capable of acting as an electrolyte, which is linked to corrosion rate. Such measurements when plotted graphically, in the form of colour coded contour maps can be a particularly useful diagnostic tool. Selected areas can then be subjected to further investigation, for example exploratory cutting-out for direct reinforcement inspection. It should be noted, however, that these methods can be sensitive to various factors including temperature (both air and surface temperatures), concrete moisture contents and reinforcement electrical continuity. Measurements should collectively be used, together with other data to interpret potential corrosion condition only at the time of measurement. Measurements should ideally be taken at regular time intervals to assess potential corrosion condition at different times of the year when controlling parameters such as temperature and concrete moisture content will be different.

It is important always to approach any structure with an open mind. The concrete, together with any other associated materials have also, therefore, been closely inspected and the exposure conditions assessed in order to identify any distress not consistent with the above and, therefore, requiring further investigation and additional testing.

Further information, with particular reference to concrete, its durability, deterioration and assessment can be sourced within a large number of publications and documents, including those listed below (footnote 8).

5.1.2.2 Data from Middlesbrough Council Laboratory Services Report No. 06 / 148

Depths of Carbonation
Depths of carbonation were not determined.

Chloride
The chloride ion contents were found approximately to range from less than 0.1% to 3.9% by weight of cement. Approximately 33% of the values were in the range upwards to 0.5%, with 22% in the range 0.5% to 1.0% and 45% in excess of 1%. 17% of the values were in excess of 2% by weight of cement.

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[8] Concrete Society Technical Reports;
No. 22: Non-structural Cracks in Concrete
No. 30: Alkali-Silica Reaction: minimizing the risk of damage to concrete
No. 33: Assessment and Repair of Fire Damaged Concrete Structures
No. 34: Concrete Industrial Floors
No. 44: Relevance of Cracking in Concrete Due to Corrosion of Reinforcement
No. 47: Durable Bonded Post-tensioned Concrete Bridges
No. 54: Diagnosis of Deterioration in Concrete Structures
Rendell F.: Deteriorated Concrete

Incremental depth sampling and analysis of the concrete, together with the obvious source of salt confirmed that the concrete probably did not contain significant chloride 'as-built'.

BRE Digest 444: 2000 gives guidance on the "estimated risk" of steel reinforcement corrosion associated with both 'cast-in' and 'ingressed' chloride. This guidance may be summarised as follows:

<table>
<tr><th colspan="14">Extracted from BRE Digest 444: Part 2: 2000 – Figures 4 and 5
Very Approximate <u>Minimum</u> Chloride Content, % by weight of cement</th></tr>
<tr><th rowspan="4">Risk Category</th><th colspan="12">For 'Cast-in' Chloride</th><th rowspan="4">For 'Ingressed' Chloride</th></tr>
<tr><th colspan="4">25years-old</th><th colspan="4">40years-old</th><th colspan="4">60years-old</th></tr>
<tr><th colspan="2">Dry</th><th colspan="2">Damp</th><th colspan="2">Dry</th><th colspan="2">Damp</th><th colspan="2">Dry</th><th colspan="2">Damp</th></tr>
<tr><th>A</th><th>B</th><th>A</th><th>B</th><th>A</th><th>B</th><th>A</th><th>B</th><th>A</th><th>B</th><th>A</th><th>B</th></tr>
<tr><td>Negligible:</td><td>0</td><td>-</td><td>0</td><td>-</td><td>0</td><td>-</td><td>-</td><td>-</td><td>0</td><td>-</td><td>-</td><td>-</td><td>0.15 to 0.35</td></tr>
<tr><td>Low:</td><td>0.4</td><td>0</td><td>0.4</td><td>-</td><td>0.4</td><td>0</td><td>0</td><td>-</td><td>0.4</td><td>0</td><td>0</td><td>-</td><td rowspan="2">0.2 to 0.6</td></tr>
<tr><td>Moderate:</td><td>1.0</td><td>0.4</td><td>0.7</td><td>0</td><td>0.7</td><td>0.3</td><td>0.45</td><td>0</td><td>0.6</td><td>0.2</td><td>0.4</td><td>0</td></tr>
<tr><td>High:</td><td rowspan="3">1.5</td><td>0.7</td><td>1.0</td><td>0.6</td><td>1.0</td><td>0.6</td><td>0.7</td><td>0.4</td><td>0.8</td><td>0.6</td><td>0.6</td><td>0.4</td><td>0.5 to 1.35</td></tr>
<tr><td>Very High:</td><td rowspan="2">1.0</td><td rowspan="2">1.5</td><td rowspan="2">1.0</td><td rowspan="2">1.5</td><td>1.0</td><td>1.0</td><td>0.7</td><td rowspan="2">1.5</td><td>0.8</td><td>0.8</td><td>0.6</td><td>Not Applicable</td></tr>
<tr><td>Ext. High:</td><td>1.5</td><td>1.5</td><td>1.0</td><td>1.5</td><td>1.5</td><td>0.8</td><td>1.0 to 1.95</td></tr>
<tr><td colspan="14">Risk categories appropriate for the concrete under discussion here.</td></tr>
<tr><td colspan="14">Note: A = where the carbonation front HAS NOT YET extended down to the reinforcement, whereas B = where the carbonation front HAS extended down to the reinforcement.</td></tr>
</table>

For concrete of this age, i.e. approaching 40years-old, containing 'ingressed' chlorides in the above proportions, BRE Digest 444 would suggest risk categories ranging from 'Negligible' to 'Extremely High' in terms of the potential for steel reinforcement corrosion.

Corrosion of the Reinforcement
Half-cell potential values (footnote 9) were found, in most of the areas surveyed, to indicate a greater than 50% probability that active corrosion was occurring at the time of survey, with a significant proportion indicating a greater 95% probability.

5.1.3 Conclusions

On the basis of the above results, in our opinion, the reinforced concrete units forming the sea wall has deteriorated and become distressed mainly as a result of generalized chloride induced corrosion, possibly exacerbated by carbonation, i.e. BRE Digest 444: Part 3 deterioration Types "C" or "D" (footnote 10).

Having carried out an appropriate survey and investigation, and classified the type of deterioration, BRE Digest 444 gives guidance on the prognosis for further reinforcement corrosion.

[9] Concrete Society Technical Report 54, "Diagnosis of Deterioration in Concrete Structures" states that values less negative than -200mV indicate a 5% risk that corrosion was occurring at the time of measurement, with values in the range -200mV to -350mV indicating a 50% risk that corrosion was occurring at the time of measurement, with values more negative than -350mV indicating a 95% risk that corrosion was occurring at the time of measurement.
[10] "Type A:" Carbonation induced corrosion with no chlorides, "Type B:" Cast-in chlorides with no carbonation, "Type C:" Ingressed chlorides with no carbonation and "Type D:" Chlorides (either cast-in or ingressed) and carbonation in combination.

5.2 PROGNOSIS

BRE Digest 444: 2000 defines the corrosion risk categories established above, for the interpretation of steel reinforcement corrosion risk and prognosis.

Extracted from Figure 6 BRE Digest 444: Part 2: 2000 Interpretation of Steel Reinforcement Corrosion Risk and Prognosis		
BRE Digest 444 Risk Category	**Description**	
	For Cast-in Chloride	**For Ingressed Chloride**
"Negligible":	No corrosion expected.	**Little or no risk of corrosion under current conditions over the lifetime of the structure.** (footnote 11)
"Low":	With normal maintenance no significant corrosion likely to occur. Some minor corrosion may be identified.	**Some corrosion possible under current conditions. Rate of corrosion likely to be low.**
"Moderate":	Some corrosion likely to occur. Rate of corrosion likely to be slow.	
"High":	Significant corrosion likely, particularly towards the end of the selected age. (footnote 12)	**Significant corrosion likely, increasing with exposure period. Rate of corrosion could be high in parts.**
"Very High":	Significant corrosion likely over considerable area.	Not Applicable.
"Extremely High":	Severe corrosion inevitable. Significant area likely to be affected.	**Severe corrosion inevitable. Significant area likely to be affected.**
(blue)	Risk categories appropriate for the concrete under discussion here.	

A key factor in the deterioration of any concrete, but particularly, as in this case, the initiation of depassivation and the propagation of corrosion of the reinforcement due to carbonation and/or chloride, is the environment of exposure.

BS 5328: Part 1: 1997 (footnote13) classifies various exposure conditions as follows:

[11] The chloride concentration and, hence, the risk of corrosion may increase with time.

[12] BRE Digest 444 describes age bands of 25 years, 40 years and 60 years for concrete containing cast-in chloride.

[13] BS 5328: Part 1: 1997 was superceded by BS EN 206-1: 2000 in December 2003. BS EN 206-1: 2000: Part 1: Specification, performance, production and conformity does not include exposure classes for concrete containing 'cast-in' chloride, 'cast-in' chloride having been consigned to history by modern specifications. However, in this particular case, in our opinion, the BS 5328 Classifications are still appropriate.

BS 5328: Part 1: 1997 Guide to Specifying Concrete Table 5, Classification of Exposure Conditions	
Environment Classification	**Exposure Conditions**
"Mild"	**Concrete surfaces protected against weather or aggressive conditions**
"Moderate"	**Exposed concrete surfaces but sheltered from severe rain or freezing whilst wet. Concrete surfaces continuously under non-aggressive water. Concrete in contact with non-aggressive soil. Concrete subject to condensation.**
"Severe"	**Concrete surfaces exposed to severe rain, alternate wetting and drying, or occasional freezing or severe condensation.**
"Very severe"	**Concrete surfaces occasionally exposed to sea-water spray or de-icing salts (directly or indirectly) Concrete surfaces exposed to corrosive fumes or severe freezing conditions whilst wet**
"Most severe"	**Concrete surfaces frequently exposed to sea-water spray or de-icing salts (directly or indirectly) Concrete in sea water tidal zone down to 1m below lowest low water**
"Abrasive"	Concrete surfaces exposed to abrasive action, e.g. machinery, metal tyred vehicles or water carrying solids
(blue)	Exposure conditions appropriate for the concrete under discussion here.

In their current condition, i.e. deteriorated and distressed, with a '???' corrosion-risk, as defined above and assuming that the above exposure conditions will remain the same, the prognosis would obviously have to allow for continued corrosion of the reinforcement spreading from currently affected areas.

As also indicated above, the corrosion rate in the future and probably also, therefore, the spread of distress is likely to be rapid.

In our opinion, however, the current condition of the various elements concerned and the prognosis could be significantly improved using one or more of the remediation processes discussed in the following Section. Further guidance can also be found within BS EN 1504 (footnote 14).

[14] BS EN 1504, "Products and systems for the protection and repair of concrete structures – Definitions, requirements, quality control and evaluation of conformity"

Part 1: Definitions
Part 2: Surface protection systems for concrete
Part 3: Structural and non-structural repair.
Part 4: Structural bonding
Part 5: Concrete injection
Part 6: Grouting to anchor or reinforcement or to fill external voids
Part 7: Reinforcement corrosion prevention
Part 8: Quality control and evaluation of conformity
Part 9: General principles for the use of products and systems.
Part 10: Site application of products and systems, and quality control of the works.

6. CONCRETE REPAIR AND REHABILITATION - GENERIC OPTIONS

6.1 GENERAL DISCUSSION

Assuming that a thorough and appropriate survey has been carried out, and having diagnosed the cause/s of deterioration, BS EN 1504-9 gives guidance, as described below in the following Tables, on the "principles and methods for remediation" of both "defects in concrete" and "reinforcement corrosion".

Principle	Principle Definition	Methods Based on the Principle
"Principles and Methods Related to Defects in Concrete"		
Principle 1 (PI)	**Protection against Ingress** Reducing or preventing the ingress of adverse agents, e.g. water, other liquids, vapour, gas, chemicals and biological agents.	**1.1: Impregnation** Applying liquid products which penetrate the concrete and block the pore system. **1.2: Surface coating with and without crack bridging ability.** **1.3 Locally bandaged cracks.** **1.4 Filling cracks.** **1.5 Transferring cracks into joints** **1.6 Erecting external panels** **1.7 Applying membranes**
Principle 2 (MC)	**Moisture Control** Adjusting and maintaining the moisture content in the concrete within a specified range of values.	**2.1 Hydrophobic impregnation.** **2.2 Surface coating.** **2.3 Sheltering or overcladding.** **2.4 Electrochemical treatment** Applying a potential difference across parts of the concrete to assist or resist the passage of water through the concrete. (Not for reinforced concrete without assessment of the risk of inducing corrosion).
Principle 3 (CR)	**Concrete Restoration** Restoring the original concrete of an element of the structure to the originally specified shape and function. Restoring the concrete structure by replacing part of it.	**3.1 Applying mortar by hand.** **3.2 Recasting with concrete.** **3.3 Spraying concrete or mortar.** **3.4 Replacing elements.**
Principle 4 (SS)	**Structural Strengthening** Increasing or restoring the structural load bearing capacity of an element of the concrete structure.	**4.1 Adding or replacing embedded or external reinforcing steel bars.** **4.2 Installing bonded rebars in preformed or drilled holes in the concrete.** **4.3 Plate bonding.** **4.4 Adding mortar or concrete.** **4.5 Injecting cracks, voids or interstices.** **4.6 Prestressing - (post-tensioning)**
Principle 5 (PR)	**Physical Resistance** Increasing resistance to physical or mechanical attack.	**5.1 Overlays or coatings** **5.2 Impregnation.**
Principle 6 (RC)	**Resistance to Chemicals** Increasing resistance of the concrete to surface deterioration's by chemical attack.	**6.1 Overlays or coatings** **6.2 Impregnation.**
NB: Various methods included above may contain products and systems not covered by the 1504 series of European standards. Inclusion of methods in this table does not imply approval or confirmation of their effectiveness.		

Cont'd…

Principle	Principle Definition	Methods Based on Principle
"Principles and Methods Related to Reinforcement Corrosion"		
Principle 7 (RP)	**Preserving or restoring passivity** Creating conditions in which the surface of the steel reinforcement can maintain or return to a passive condition	**7.1: Increasing cover to the reinforcement with additional cementitious mortar or concrete.** **7.2: Replacing chloride-contaminated or carbonated concrete** **7.3 Electrochemical realkalisation of carbonated concrete** **7.4: Realkalisation of carbonated concrete by diffusion** **7.5: Electrochemical chloride extraction**
Principle 8 (IR)	**Increasing resistivity** Increasing the electrolytic resistivity of the concrete	**8.1: Limiting moisture content of the concrete by surface treatments, coatings or sheltering**
Principle 9 (CC)	**Cathodic control** Creating conditions in which potentially cathodic areas of reinforcement are unable to drive an anodic reaction	**9.1: Limiting oxygen content (at the cathode) by saturation of the concrete or surface coating**
Principle 10 (CP)	**Cathodic Protection** Polarising the steel reinforcement cathodically so as to reduce the rate of anodic reaction	**10.1: Impressed current systems** **10.2: Sacrificial anode systems**
Principle 11 (CA)	**Control of anodic area** Creating conditions in which potentially anodic areas of reinforcement are unable to take part in the corrosion reaction	**11.1 Painting reinforcement with coatings containing active pigments** **11.2: Painting reinforcement with barrier coatings** **11.3: Applying anodic inhibitors to the concrete**
NB: Various methods included above may contain products and systems not covered by the 1504 series of European standards. Inclusion of methods in this table does not imply approval or confirmation of their effectiveness.		

In our opinion, the successful repair and refurbishment of any structure should, subject to future design-life requirements ideally return the various concrete elements to a better-than-new condition; the "as-built" condition of any deteriorated and distressed structure, now proposed for refurbishment, was such that failure has occurred within it's useful life.

In our opinion, a structure of this type, in this condition, could be repaired and refurbished, using the above principles and the 'state-of-the-art' technologies available today with the aim of providing an indefinite additional life-in-service.

The remedial strategy could range from a simple 'make-safe' (with or without holding repairs) strategy, to a high-Specification, 'one-stop' strategy, with an allowance for a limited number of maintenance re-visits, generally to SAY re-apply surface coatings.

The former would obviously suit a limited budget and / or where the future life of a structure was either limited or uncertain. Such a strategy would allow for the elevations to be 'made-safe' (footnote 15) from the risk of falling debris

[15] 'Made-safe', in this context does not necessarily mean that a structural appraisal has been carried out, or that the structure is deemed to be sound and safe from failure or collapse, either wholly or in part. The elevations would be 'made-safe' from the risk of falling debris following an appropriate external survey. However, the concrete would continue to deteriorate, perhaps at an ever-increasing rate and further loose material would develop. In our experience, such structures should be regularly monitored and further 'make-safe' works carried out as necessary. It should also be noted that successive 'make-safe' works could involve the removal of perhaps significant amounts of concrete and some structure's may also require careful monitoring by a Structural Engineer.

with an option for simple 'holding-repairs' (footnote 16), to extend the safe condition of the elevations for up to SAY 5 years. This safe condition could obviously be further extended, with periodic re-visits, assuming that the elements concerned were and remain structurally sound, until the structure is either re-developed, or refurbished.

The detailed design of an appropriate refurbishment strategy to satisfy the latter, using the available technologies can also be tailored to suit specified limits and / or requirements, for example, in terms of budget, longevity and appearance using a combination of one or more of the techniques discussed, in general terms below.

6.2 CONVENTIONAL OR TRADITIONAL PATCH-REPAIR

For conventional or traditional concrete patch-repair all of the defective concrete, defined as all carbonated and/or chloride contaminated concrete in contact with the steel, should be removed, the steel cleaned and treated, and the concrete then reinstated using proprietary concrete repair materials and good practice.

> **NB:** If areas of steel were to be left encapsulated within deteriorated concrete, as defined by conventional concrete repair criterion, further deterioration could take place and subsequent distress could possibly occur within the designed life-to-first-maintenance.

This strategy would satisfy BS EN 1504: Part 9, Principle 7 ("Preserving or restoring passivity") and in particular principle 7.2 ("Replacing chloride-contaminated or carbonated concrete").

For chloride contamination, as indicated above, BRE Digest 444: Part 2 recognises values, by weight of cement, in excess of 0.2% for "ingressed" chloride and 0.4% for "cast-in" chloride as carrying an elevated risk of inducing reinforcement corrosion.

A conventional or traditional concrete patch-repair strategy, depending upon the prognosis discussed above and the level of Specification should last for between 5years and 15years. Further information concerning concrete repair can be sourced within various publications and documents, including those listed under footnote (17).

6.2.1 Note

No matter what processes have been involved in the deterioration of the concrete the above conventional patch-repairs or reinstatement will have to be carried out at least to the areas of physically damaged, disrupted and / or delamination. The various methods discussed below address the areas where the reinforcement is encapsulated within currently 'sound', but carbonated / chloride contaminated concrete, without the need to remove this concrete. These methods, therefore, limit the quantity of relatively expensive, disruptive and time-consuming cutting-out and subsequent patch-repair needed to achieve the required / specified finished product.

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[16] Simple 'holding-repairs' would generally comprise cementitious slurry coating of exposed reinforcement and the scared concrete surfaces. The slurry coating would limit further corrosion of exposed steel and temporarily seal disrupted concrete surfaces. It should be noted that this option may be considered aesthetically unacceptable.

[17] Further information can be sourced within the following:

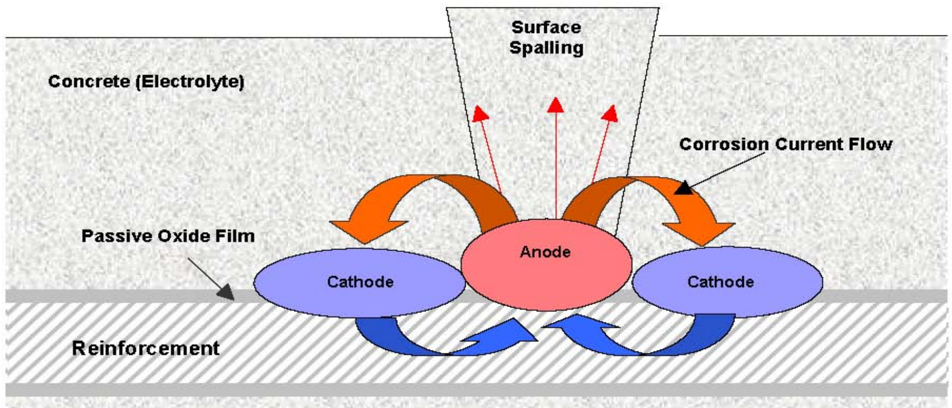
- BS EN 1504, "Products and systems for the protection and repair of concrete structures – Definitions, requirements, quality control and evaluation of conformity", Part 3: "Structural and non-structural repair".
- Concrete Society Technical Report No. 26, "Repair of concrete damaged by reinforcement corrosion".
- Concrete Society Technical Report No. 38, "Patch repair of reinforced concrete subject to reinforcement corrosion".
- CIRIA, "Corrosion Damaged Concrete Assessment and Repair".
- Thomas Telford, "Repair and Strengthening of Concrete Structures – a guide to good practice".
- Blackie Academic & Professional, "Repair of Concrete Structures".
- ACI International/ BRE/ Concrete Society/ International Concrete Repair Institute, "Concrete Repair Manual, Volume 1 and Volume 2".
- BRE Report, "Repair and maintenance of reinforced concrete".
- BRE IP 11/88, "A Method for Evaluation of Repairs to Reinforced Concrete in Marine Conditions".
- ICE, "Inspection, Maintenance and Repair of Maritime Structures Exposed to Material Degradation caused by a Salt Water Environment".

6.3 ELECTROCHEMICAL REHABILITATION.

6.3.1 General

The corrosion of steel in concrete is an electrochemical process with anode and cathode reactions as illustrated below:

Figure II/i: Anodes and Cathodes



The anode reactions are as follows:

1. Fe **>** Fe^{2+} + $2e^-$

2. Fe^{2+} + $2OH^-$ **>** $Fe(OH)_2$

3. $4Fe(OH)_2 + o_2 + 2H_2O$ **>** $4Fe(OH)_3$ **>** $2Fe_2O_3.H_2O + 4H_2O$ (RUST)

The cathode reaction is as follows:

1. $½O_2 + H_2O + 2e^-$ **>** $2OH^-$

Reactions at the anode produce rust, which expands to produce the classical symptoms of surface spalling.

A patch-repair strategy involving only those areas of physically damaged, disrupted or delaminated concrete, only addresses the anodes, leaving the cathodes untreated (except for the effects of any subsequently applied coatings), although the concrete in these areas is potentially similarly deteriorated with respect to carbonation and/or chloride contamination. The reinforcement within a patch-repair will become a cathode with the surrounding, former cathodes becoming anodes, thus causing the onset of "incipient anode" corrosion surrounding the patch-repairs, as illustrated below.

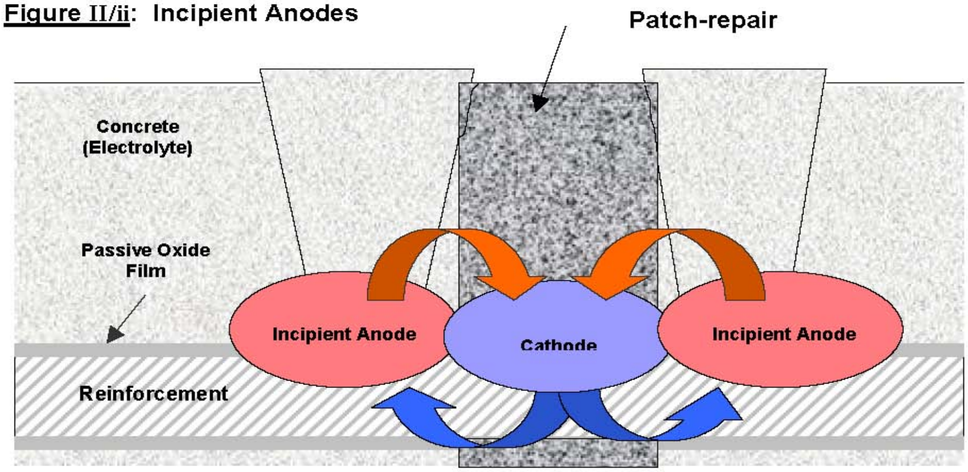


Figure II/ii: **Incipient Anodes**

Electrochemical treatments artificially modify the polarity of an existing reinforcement system, with the steel maintained, at least for the period of the treatment, as a cathode.

6.3.2 Sacrificial Anodes or Galvanic Cathodic Protection

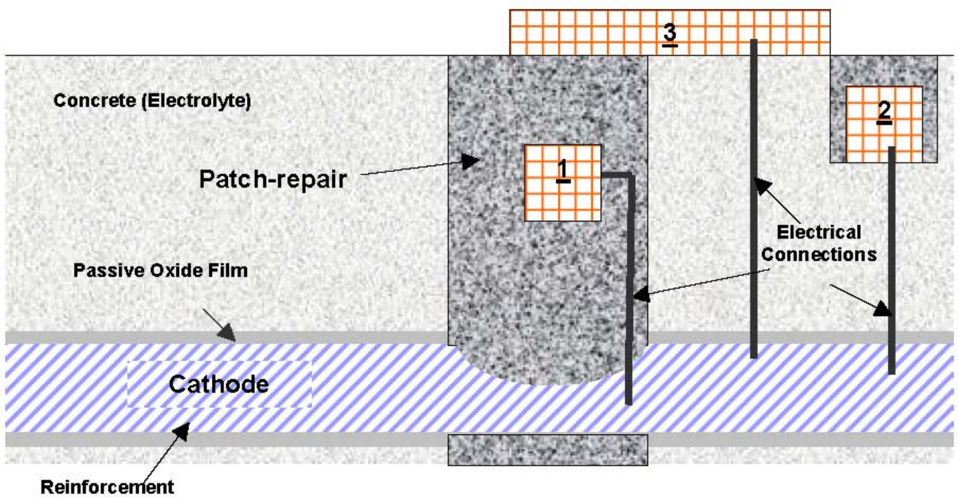


Figure II/iii: **Sacrificial Anodes (1, 2, and 3)**

The use of sacrificial anodes, fixed with electrical continuity to the reinforcement, installed either within patch-repairs (**1**), and / or within areas of 'sound' but carbonated / chloride contaminated concrete (**2**), or fixed externally (**3**), can prevent, or at least minimise the risk of incipient anode corrosion.

This strategy would satisfy BS EN 1504: Part 9, Principle 10 ("Cathodic protection or prevention") and in particular principle 10.2.

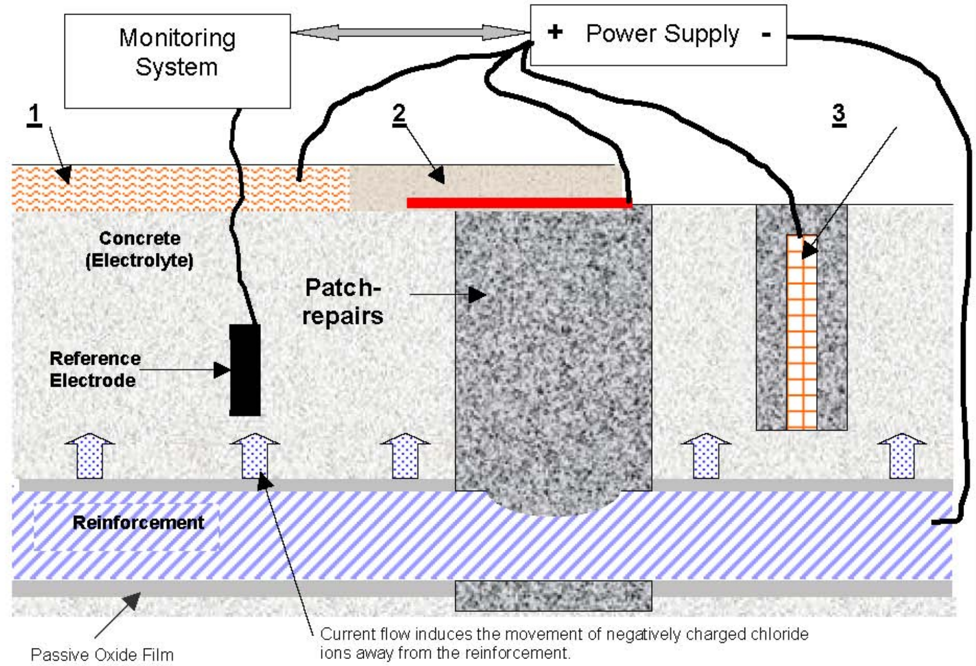
The life expectancy of sacrificial anodes is advised to be in the region of 10years to 15years, although it should be noted that the long term durability and effectiveness of this treatment, although expected to be good has not yet been proven (footnote [18]). As a known technology for the protection of the hulls to steel ships, however, sacrificial anodes have been available for over 150 years and some permanent electrochemical installations or Cathodic

[18] Sacrificial anodes have now been performing in the UK for 10years. The Author is not aware of any failures.

protection systems have been designed to include sacrificial anodes, rather than externally applied paint or internally installed, discrete anode systems.

6.3.3 Permanent Impressed Current Installations or Cathodic protection (CP)

Figure II/iv: Permenant Impressed Current Cathodic Protection



Permanent impressed current installations or Cathodic protection (CP) systems are a well-proven technique for prevention of corrosion of metallic structures in aggressive environments. For reinforced concrete a permanent anode system is installed with a small current flow (10 to 20 mA/m^2) used permanently to maintain the steel in a passive, cathodic state.

Various anode systems have been developed including surface applied conductive paint (**1**), activated titanium mesh within paint or cementitious overlays (**2**) and discrete titanium rods in drilled holes (**3**). This range of systems means that virtually any structure, or surface whether exposed or hidden can be protected using CP.

Monitoring and control can be achieved remotely by computer with the benefit that the corrosion-state is always under control.

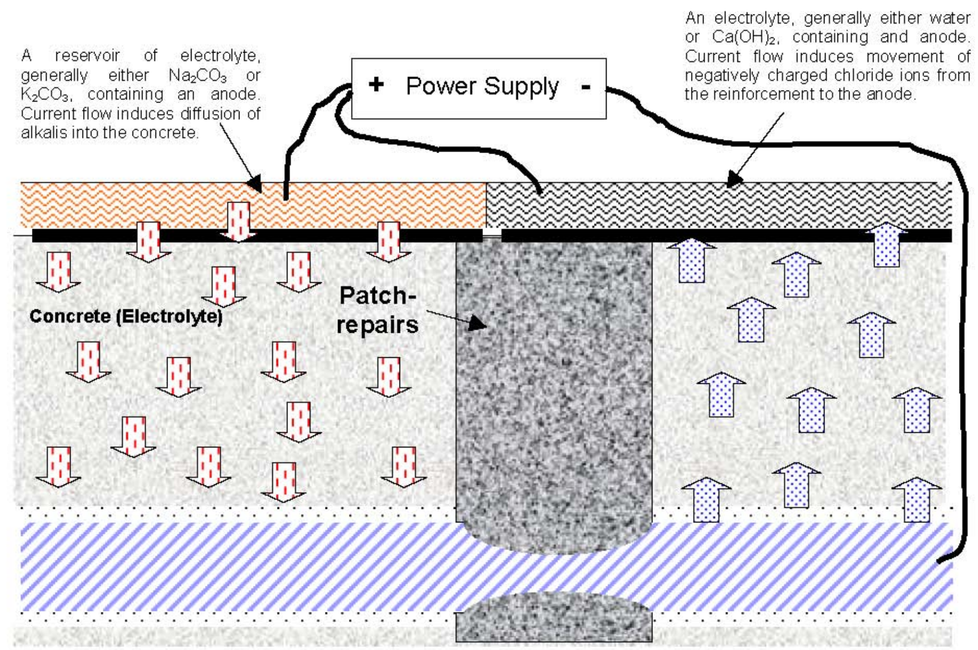
This strategy would satisfy BS EN 1504: Part 9, Principle 10 ("Cathodic protection or prevention") and in particular principle 10.1.

The condition of the structure after SAY 5 years would be significantly better than immediately following the repairs due to the additional beneficial effects of chloride removal and alkali evolution (re-alkalisation) within the concrete immediately surrounding the steel.

The life expectancy of a CP system would be 15 to 30 years with a minimum of maintenance, dependent on system components.

6.3.4 Temporary Impressed Current Electrochemical Installations

Figure II/v: Temporary Impressed Current Installations



Temporary impressed current electrochemical installations may be viewed as short term, high powered cathodic protection (CP), designed relatively rapidly to rehabilitate the cover concrete and the steel / concrete interface.

An anode system, usually consisting of an activated titanium mesh, or similar, installed onto the concrete surfaces and within a suitable electrolyte reservoir will be connected to the reinforcement. An electrical current of approximately ranging from $0.5A/m^2$ to $2A/m^2$ will then commonly be used to induce a migration into and out-of the electrolyte.

In the case of re-alkalisation, the migration of an alkali (usually sodium carbonate or potassium carbonate) into the concrete between the reinforcement and the surfaces will re-passivate steel encapsulated within carbonated concrete. An outward migration of free, unbound chloride contaminants, within the concrete between the reinforcement and the surfaces will also take place. This process is known as desalination or chloride extraction.

Renewal of alkalinity within the cover concrete can be achieved within 3 to 14 days with the removal of free, unbound chlorides within 1 to 3 months, depending upon the quality of the concrete and the extent of deterioration / contamination.

Following treatment, the anode system would be removed.

The suitability of a structure or element for these treatments will of course be dependent on a number of factors including size of sections, access to all deteriorated faces, degree and provenance of chloride contaminants and subsequent requirements for maintaining appearances.

These strategies would satisfy BS EN 1504: Part 9, Principle 7 ("Preserving or restoring passivity") and in particular principles 7.3, 7.4 and 7.5.

The life expectancy of a temporary electrochemical treatment should be 10 to 15 years although it should be noted that the long term durability and effectiveness of these treatments, although expected to be good, has not yet been proven.

6.4 CORROSION INHIBITORS.

The prevention or limitation of corrosion of steel in concrete can be achieved by the use of corrosion inhibitors. Three generic types of corrosion inhibitors are available, namely calcium nitrite, sodium monofluorophosphate and amino alcohol.

These compounds, with pH levels of between 8 and 11 penetrate or migrate through the cover concrete, in either the liquid or vapour phases and are attracted towards embedded reinforcement where they form a protective film. The protective film limits anodic ionization at the steel surfaces and obstructs the available free oxygen, which prevents the cathodic part of the corrosion reaction. Potentially deleterious chloride ions can also be displaced from the steel surfaces.

Research and development of these methods of concrete protection and rehabilitation have been undertaken on the continent and in the United States of America for a number of years. The technology was originally developed for the protection of metals exposed to atmospheric corrosion and was first used in conjunction with reinforced concrete in the USA in the early 1980's.

The technology was subsequently introduced into the UK, with various products including; liquid, powder or slurry admixtures for fresh concrete; surface applied aqueous impregnation's, gel injection's and powder filled capsules for existing concrete; additives for various repair grouts and mortars. Specific Vapour Corrosion Inhibitors are also available in various forms including impregnated insulation foam or as paint coatings for the protection of exposed steelwork.

As with the electrochemical techniques detailed above, the use of corrosion inhibitors requires that only the detectable damage needs to be repaired. Concrete, which is carbonated, and/or chloride contaminated (footnote 19) but otherwise sound can, in most cases be left in-situ.

This strategy would satisfy BS EN 1504: Part 9, Principle 9 ("Cathodic control", i.e. principle 9.2) and Principle 11 ("Control of anodic area", i.e. principle 11.3).

Although the life expectancy of these treatments should be at least 5 to 10 years (footnote 20), some products and applications may, in some circumstances, require regular re-treatments. For example, although liquid products, applied by brush, roller or spray would generally only require a single application, some gel injections or powder filled capsules, injected/installed into pre-drilled, corked and capped holes, could require re-application or renewal at regular maintenance intervals. In some environments, e.g. where warm, humid and/or salty, such maintenance, at least initially, could be as regular as 6 monthly, whilst the inhibitors penetrate, with subsequent intervals perhaps on a 2 to 3 year cycle. However, protection would be provided as long as the maintenance programme continued and gel injections or powder filled capsules perhaps have the advantage of potentially protecting reinforcement beneath hidden surfaces.

6.5 SURFACE PROTECTION SYSTEMS

Although coatings can be applied simply for decorative purposes, surface treatments (including coatings) in the context of the concrete repair and refurbishment Industry have generally been applied as the first line of defence in a protection system, i.e. the treatments have been applied primarily to cover and / or seal the surfaces to ensure that the concrete does not continue to deteriorate as a result of further exposure to the environment.

The application of such treatments would satisfy BS EN 1504: Part 9, Principle 1 ("Protection against ingress", i.e. principles 1.1, 1.2 and 1.3), Principle 2 ("Moisture Control", i.e. principles 2.1 and 2.2), Principle 5 ("Physical Resistance/Surface Improvement, i.e. Principles 5.1 and 5.2), Principle 6 ("Resistance to Chemicals", i.e. Principle 6.1) and Principle 8 ("Increasing Resistivity", i.e. Principles 8.1 and 8.2).

Three main types of surface treatment are available:

1. Pore-liners. Hydrophobic impregnation treatments which line the pores and repel water, whilst allowing the concrete to 'breath'.

[19] The effectiveness of some products is to be limited to a maximum chloride ion content.

[20] it should be noted that the long-term durability and effectiveness of these treatments, in the UK, although expected to be good have not yet been proven

2. Pore-blockers. Impregnation materials applied partially or fully to fill the pores and seal the surfaces.

3. Coatings and coating systems. Materials comprising cementitious pore fillers or renders, thin barrier coatings or breathable coatings.

Different types of coatings will be more or less appropriate to a specific application depending upon the environmental conditions prevailing and the requirements for the finished 'product'.

A conventional concrete repairs strategy would normally require the use of a proprietary anti-carbonation coatings system to minimise further deterioration through carbonation. The coatings are formulated to allow the passage of water vapour, but to prevent the ingress of carbon dioxide and other deleterious substances such as chloride salts. These coatings in some cases may also produce a natural re-alkalising affect and should also allow the concrete to dry; perhaps modifying the potential, in the long-term, for further corrosion in the presence of chloride.

Following removal of the anode system installed as a part of a re-alkalisation or de-salination strategy surface coatings would normally be required to prevent further ingress of aggressive chemicals or leaching of alkalis which could re-activate corrosion. In this case the coating system would probably be similar to that used following a conventional concrete repairs strategy.

No additional surface coatings would be required after the installation of a CP system to limit further ingress of aggressive chemicals. However, some CP systems use anode components incorporated within coatings.

In some cases, the surfaces following repairs may not be suitable for the application of coatings. For example, rough surfaces or excessively voided surfaces may require pore-filling first, to prevent 'pin-holing'. Rougher surfaces may require the application of thin, high-performance renders to produce the required surface for coating. These applications may also have a decorative effect, in terms of hiding or masking repairs.

As the first line of defence, the coatings system obviously bears the brunt of the various environmental factors which were probably a significant contribution to the deterioration and resultant distress which lead to the repair and refurbishment of the structure in the first place. The coatings will, therefore, be subjected to wear and tear and will require periodic maintenance.

6.6 STRUCTURAL STRENGTHENING

In cases where the structural integrity of an element or structure has been called into question it may be cost effective to augment existing by installing additional reinforcement, perhaps using stainless. As an alternative, however, steel plate bonding or carbon-fibre could be used as external reinforcement.

The installation of additional, or replacement reinforcement would generally be most cost-effective within the cut-outs for concrete patch repairs, or where extensive cutting-out had taken place, i.e. where specific cutting-out would not be necessary.

The use of steel plate bonding or carbon fibre external reinforcement would generally be more cost-effective where elements were not significantly distressed. The former requires both industrial adhesives and the installation of 'peel-off' bolting whereas the latter would generally only require industrial adhesives. Carbon-fibre is also more flexible, available as either rigid plates or bandages (the latter allowing for the wrapping of elements), together with perhaps significant weight and space savings coupled with the benefit of generally easier and quicker installation.

6.7 NOTE

All materials employed in any refurbishment, regardless of detailed strategy should be of appropriate quality and should generally comprise tried and tested proprietary systems, manufactured under BBA or equivalent accreditation and installed by reputable Contractors covered by ISO 9002 (formerly BS5750) accreditation.

7. SPECIFIC RECOMMENDATIONS FOR REMEDIAL WORKS

NB: The design of a specific remedial works strategy will obviously be influenced by a potentially extensive array of factors, many outside our current knowledge of this project, and our recommendations must necessarily be limited to a simplistic clarification of generic options, intended to enable and encourage a focus, 'on a selection of potential trees in the forest' and invite feedback, during which additional information can be factored in.

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7.1 REPAIR AND REFURBISHMENT

The appropriate Specification for the repair and refurbishment of the reinforced concrete forming the sea wall would be dependent upon a number of factors, including those discussed above and, in our opinion, could comprise either conventional concrete repairs and coatings, electrochemical treatments comprising either, sacrificial anodes, temporary or permanent impressed electrical installations, or corrosion inhibitors. Each of these systems has been used successfully in the UK when installed using appropriate, quality materials and a reputable specialist contractor.

In this particular case, in our opinion, our investigations, together with those results reported by Middlesbrough Council laboratory Services and in particular the levels and provenance of the chloride and the ½ cell potential values recorded would suggest up to 3No. cost-effective options. The options are described below, in order of increasing costs, together with the limitations or potential risks associated with each, i.e. as the level of risk decreases the initial costs will increase.

We would also point out that any specification, including those described below, will be subject to ongoing maintenance such as re-application (over-coating) of coatings and the replacement of system components. The maintenance cycle and associated costs will vary depending upon the initial specification and system/s employed.

Option 1 – 'Do Nothing' or 'Holding-Repairs'
Although 'do nothing' is obviously an option, it will have some consequences that should be considered.

As the concrete has deteriorated to the extent that corrosion of the encapsulated reinforcement has been initiated, without action, the concrete will continue to deteriorate and further spalling will occur. This further spalling will represent a potential future risk in terms of falling debris and, eventually, the potential for structural failure.

In our opinion, therefore, the 'do nothing' option carries with it a requirement for continual monitoring, with periodic further 'make-safe' works.

In our experience periodic 'make-safe' works, i.e. the removal of loose material, on this type of structure, in this type of environment, would be expected on at least an annual basis, say during the Spring.

However, 'holding-repairs', i.e. the application of a cementitious slurry to all areas of spalled concrete and associated exposed reinforcement could, cost-effectively, extend the periods between 'make-safe' works to perhaps 2yearly.

Option 2 - Conventional Concrete Patch-Repairs
A brief, generic specification would be as follows:

i) Prepare and clean all concrete surfaces.

ii) Carry out traditional concrete patch-repairs using a proprietary repair system.
Note: This will almost certainly require the re-repair of any existing, or 'previous' repairs. Failure to do this will require some body to warranty such previous repairs, which may have been implemented using more or less unknown materials, methods and practice. Specialist Contractors may be reluctant to warranty the work of others.

NB: In our opinion, this strategy would normally be effective, with a life-to-first-maintenance of 5years to 10years. However, in this particular, 'Most Severe' environment, perhaps a maximum of 5years would be realistic. Under normal circumstances, in the absence of any chloride contamination, maintenance requirements would generally be limited to cleaning, with perhaps only minor, isolated repairs to be expected. In this particular case, however, with the chloride levels recorded here more, and perhaps very extensive repair, caused by incipient anode corrosion, would be required at maintenance intervals.

Option 3 - Conventional Concrete Patch-Repairs augmented with Corrosion Inhibitors or Sacrificial Anodes
A brief, generic specification would be as follows:

i) Prepare and clean all concrete surfaces.

ii) Carry out traditional concrete patch-repairs, but incorporating corrosion inhibitors or sacrificial anodes in order to arrest any potential for incipient anode corrosion.
Notes:
1. This will almost certainly require the re-repair of any existing, or 'previous' repairs. Failure to do this will require some body to warranty such previous repairs, which may have been implemented using more or less unknown materials, methods and practice. Specialist Contractors may be reluctant to warranty the work of others.

2. The extent of chloride contamination, in many areas of this structure, would probably be beyond the reliable performance parameters of corrosion inhibitors.

NB: In our opinion, this strategy would again be effective, under normal circumstances, with a life-to-first-maintenance of up to 15years with sacrificial anodes. However, in this particular, 'Most Severe' environment, perhaps a maximum of 10years would be more realistic. However, with the risk of incipient anode corrosion addressed maintenance should be limited. The specific materials manufacturers would need to be consulted to confirm the life-to-first-maintenance issues with respect to specific products.

Under normal circumstances, for both **Option 2** and **Option 3** above, we would recommend coatings, or another surface protection system, as a first line of defence, to protect the repairs and provide an aesthetically improved finish. However, in our opinion, any such system, in this most severe environment, would be relatively short-lived and could become a maintenance, 'nightmare', requiring re-coating on a very regular basis.

7.2 FUTURE MONITORING

Any repaired and refurbished structure or element, unless the exposure conditions were to be significantly altered, e.g. external to internal, will continue to be subjected to natural weathering and ageing, in addition to any artificial or man-made factors, specific to the usage of the structure or element concerned. Certain components (of either the structure or refurbishment) will, therefore, be more or less susceptible to future deterioration and may require regular maintenance in order to optimise durability, minimise future costs and achieve the required life-expectancy.

'De Sitter's Law of Fives', for example, quantifies the effect on whole-life costs of decisions made at different stages in the life-cycle of a structure. It could be expressed as follows:

> £1 spent getting the structure designed and built correctly is as effective as £5 spent in subsequent preventative maintenance in the pre-corrosion phase while carbonation and chlorides are penetrating inwards towards the steel reinforcement. In addition, this £1 is as effective as £25 spent in repair and maintenance when localised active corrosion is taking place. In turn, this is as effective as £125 spent when generalised corrosion is taking place and where major repairs are necessary, possibly including strengthening or the replacement of complete members.

Having spent between "£25" and "£125" repairing and refurbishing a structure it may, therefore, be considered prudent to instigate a programme of future monitoring so that any future maintenance is carried out at the right time.

Furthermore, as some of the techniques discussed above involve relatively new processes which, perhaps, could not be considered to have a long-term, proven, track record, a programme of regular monitoring could provide assurances and confirm that the strategy has and will continue to be effective.

8. APPENDIX A: MIDDLESBOROUGH COUNCIL LABORATORY SERVICES, REPORT NO. 06/148

MIDDLESBROUGH COUNCIL
Laboratory Services
Cargo Fleet Lane
Middlesbrough

HARTLEPOOL BOROUGH COUNCIL

Middlesbrough moving forward

Stockton-on-Tees BOROUGH COUNCIL

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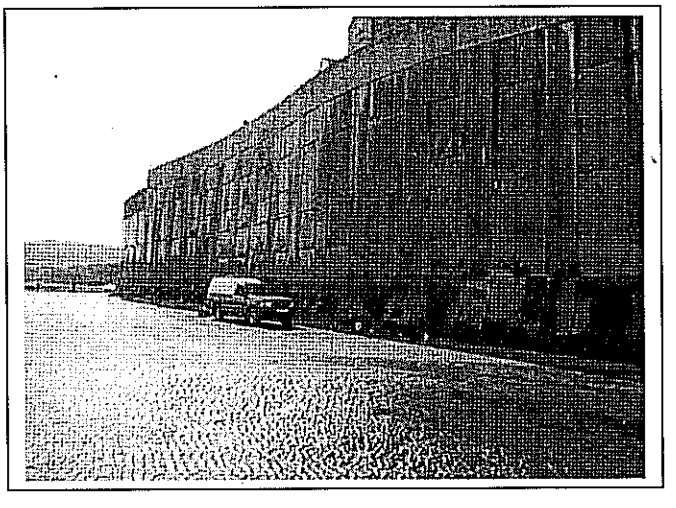
Concrete Corrosion Testing Robin Hoods Bay Sea Wall



UKAS TESTING 0678

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Contents

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TEST METHODS

The method of test is given in the schedule of tests included as part of this report.

SCOPE OF REPORT

In many cases the results of tests have been summarised so that only that information deemed essential to the client has been presented. In these cases a full and complete test report is held by the laboratory and can be produced on request.

INTRODUCTION

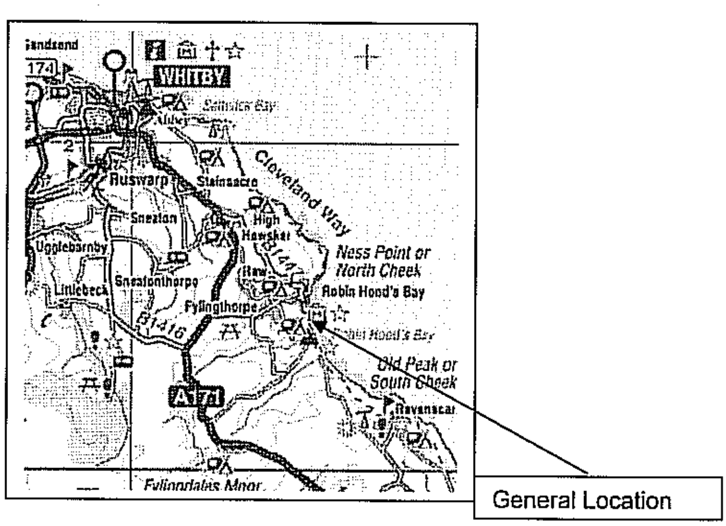
This report is a factual report only of the investigation, resultant insitu and laboratory tests performed as part of the assessment of the sea wall at Robin Hoods Bay.

COMMISSION

This report was commissioned by Mr. M Lloyd of Scarborough Borough Council, Engineering and Harbour Services, Town Hall, St Nicholas Street, Scarborough, North Yorkshire, YO11 2HG. Order number 401209 was issued to cover the work carried out.

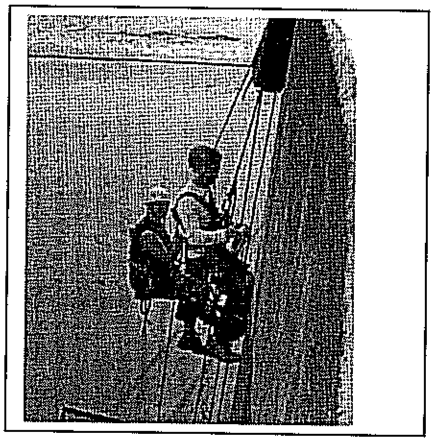
LOCATION OF SITE

The sea wall is located on the coastal footpath which runs above the beach at approximate grid reference 495382 504934.



ACCESS TO THE SITE

Access to the test area was gained from the beach on a receding tide. Abseil techniques were employed to access the wall. The abseil team used various locations on the top of the sea wall to secure the access ropes.



SITE WORK

The site work was carried out on the 25th to the 28th September 2006. A further day on the 29th September was used to repair the access holes.

The following areas of the sea wall were selected for test as a representational cross section of the structure. The panel / column numbers relate to the count from the slipway onto the beach. The average temperature during the test period was 18°C. No correction to the values obtained due to the effect of temperature was required.

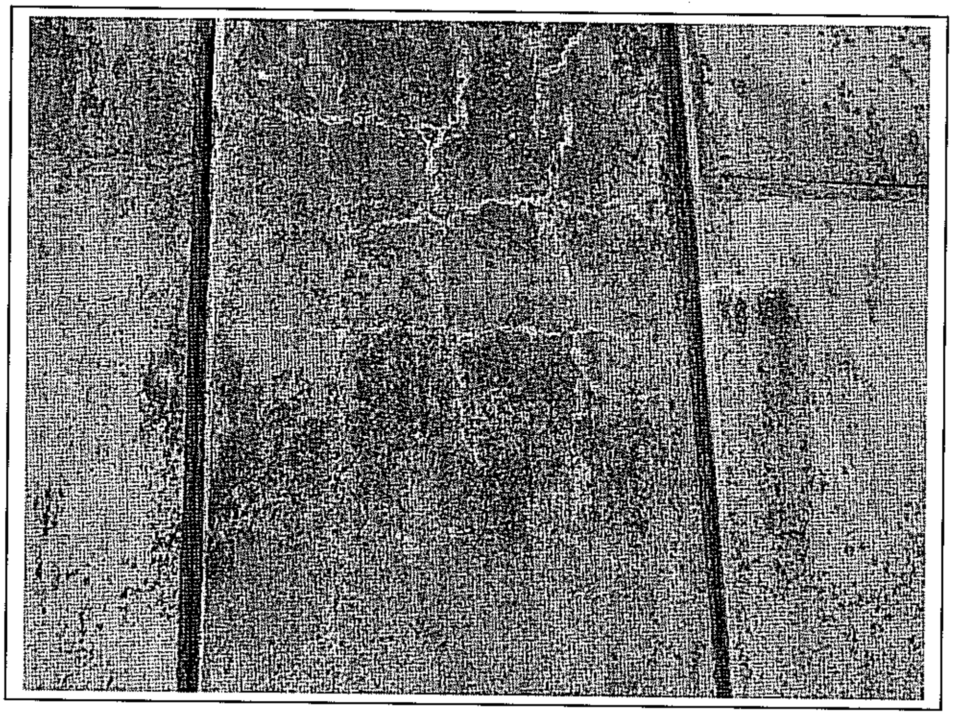
Location
Panel 1
Column 2
Column 3 (Excluding Parapet)
Parapet Wall above and right Column 5
Bottom Panel to RHS of Column 5
Column 23
Parapet Wall left of Column 23
Top half of first panel left of column 23
Middle Panel left of column 23
Lower Panel left of column 23
Column 37
Column 41
Parapet to top of Panel right of column 41
Top half panel right of column 41
Full panel in centre right of column 41
Full Panel at bottom right of column 41

Delamination (Hammer) Survey

A partial delamination survey was carried out using the method defined in Departmental Advice not BA35/90 (Amended January 1993) whereby the structure is tested on a similar grid pattern to the half cell testing. A light hammer strikes the surface of the concrete and a 'ringing' or dull sound is heard where delamination or voids are located in contrast to a solid 'thud' where the concrete is sound.

It was visually evident where there areas were due to cracking and spalling.

The picture below shows where the reinforcement in the column is corroding and reflective cracking is starting to push the concrete away.



Chlorides

Chlorides can be either

- Fixed - already in the constituents which make up the concrete (Aggregates, concrete or additives).
- Free - They are induced into the concrete through pores in the concrete

Chlorides from the environment enter the concrete and reside as free chlorides in the pore water and are particularly aggressive to embedded steel. In this case the chlorides come from the sea water and marine conditions which prevail on the site.

Chlorides can enter the structure through cracks in the face of the structure, leaking construction joints and spalled areas exposing the concrete matrix to the elements. It is important to establish the penetration profile of the chlorides.

The level of chloride permitted in concrete depends on the type of and proposed use of the concrete. Table 10 of BS EN 206 gives the maximum amount of chloride based on the cement content as follows

Table 10 — Maximum chloride content of concrete

Concrete use	Chloride content class[a]	Maximum Cl^- content by mass of cement[b]
Not containing steel reinforcement or other embedded metal with the exception of corrosion-resisting lifting devices	Cl 1,0	1,0 %
Containing steel reinforcement or other embedded metal	Cl 0,20	0,20 %
	Cl 0,40	0,40 %
Containing prestressing steel reinforcement	Cl 0,10	0,10 %
	Cl 0,20	0,20 %

[a] For a specific concrete use, the class to be applied depends upon the provisions valid in the place of use of the concrete.

[b] Where type II additions are used and are taken into account for the cement content, the chloride content is expressed as the percentage chloride ion by mass of cement plus total mass of additions that are taken into account.

The determined chloride content values quoted in this report are based on an assumed cement content of 14% as no actual concrete batching records are available.

Due to the severe exposure, the sea wall can be classed as Chloride content class Cl 0.20 giving a maximum chloride content of 0.2% by mass of cement.

Half cell potential readings were taken across the face of the selected panels and columns to determine to potential for steel corrosion. The readings are also used to identify potentially high areas for chloride sampling. The relationship between half cell potential and risk of corrosion when a copper / copper sulphate reference electrode is as follows

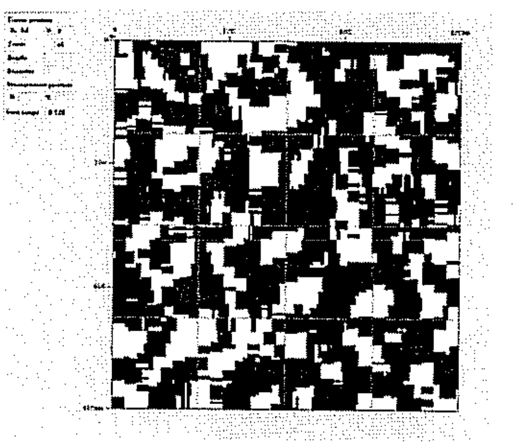
Half Cell Potential	Risk of Corrosion
Numerically less than -200 mV	5%
-200 to 350 mV	50%
Numerically Greater than -350 mV	95%

Readings were taken on a nominal 0.5m grid on the panels, measured 100mm in from the panel edge. On the columns, a 300mm grid was employed, again measured 100mm in from the column edge.

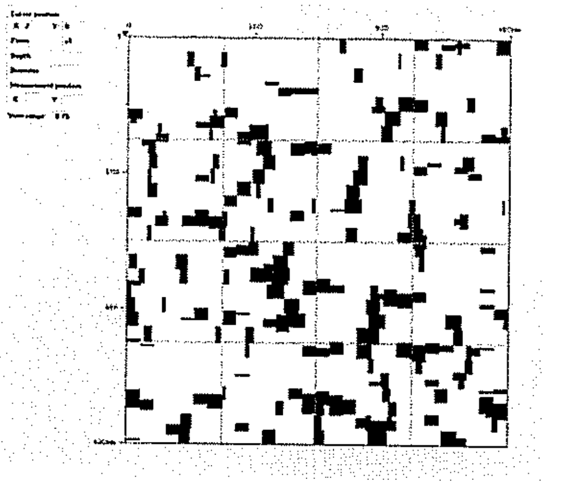
Reinforcement Cover

Two methods of determining the reinforcement detail were used. A Hilti Ferroscan was used initially to determine the pattern and a normal cover meter was used later to detect reinforcement bars to attach the half cell probe to. Below are some pictorial views obtained from the Ferroscan.

This view looks at the detail of metallic objects in the concrete at a depth of 120mm. It appears very cluttered and there appears to be no definite pattern to the steel.

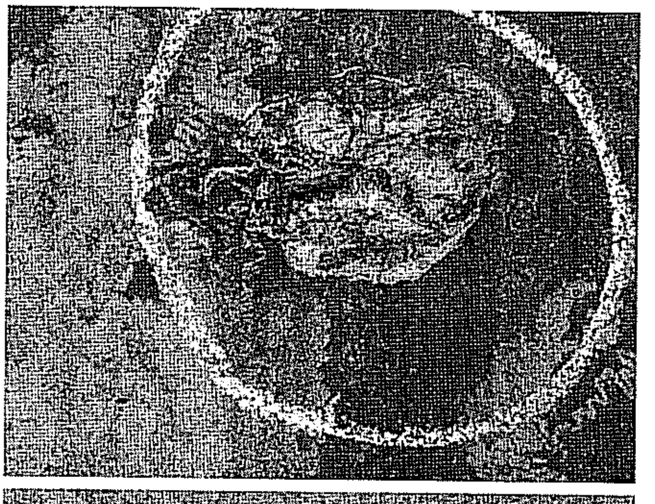


This view reduces the range to 75mm. This has removed a great deal of 'noise' from the scan (See Notes Section of Report). One of the objectives of the survey was to determine the cause of the rust staining on the surface of the concrete. Close visual inspection showed 'eruptions' on the surface of the concrete. When investigated by removing the surface of the concrete, there were two causes.

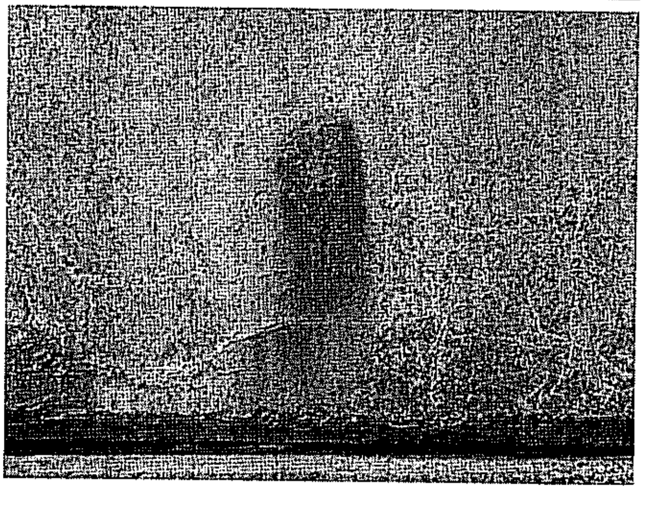


The cover to the steel measured by Ferroscan and cover meter was in the order of 70mm to 80mm in the areas tested. This was confirmed by physical measurements in the holes drilled to connect the half cell. A full cover survey was not carried out due to time constraints. Visual examination of the reinforcement in the areas broken out did not show any signs of bar corrosion or wasting.

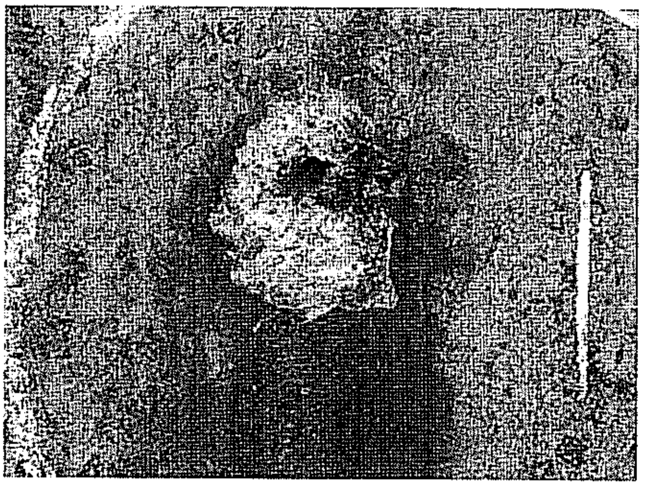
The first was pieces of tie wire, used to construct the steel cage before the concrete was poured were very close to the surface.



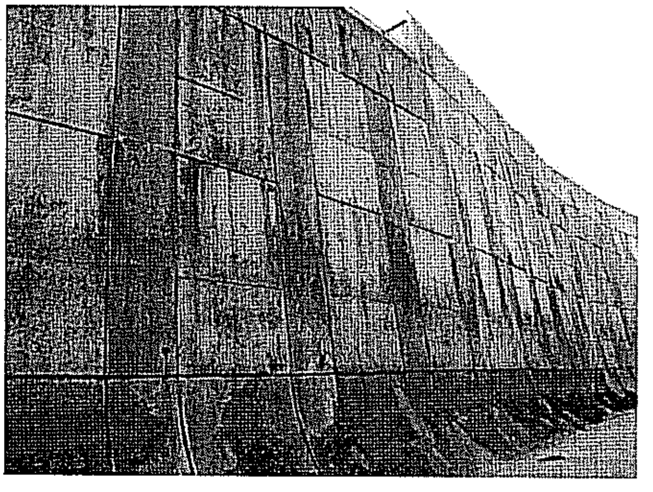
Secondly samples removed from other stained areas appeared to have pieces of iron in the matrix of the concrete. On returning samples to the laboratory and inspecting them under a microscope, it was discovered that iron ore was contained in the sandstone gravel. This has oxidised, expanded and caused the eruption of the surface.



The removal of the surface reveals iron ore type material under the surface.



Other staining appears to be caused by the joints between pours not being completely water proof. This is evident from the amount of staining running down from the tops of panels and joints.



Summary

Half Cell Summary - All readings taken were in excess of -350 mV which indicates that there is a 95% chance of corrosion of the reinforcing steel taking place.

Chloride Content Determination - with the exception of three locations, the chloride results from the surface to the depth of reinforcement are in excess of the recommended 0.2% given in BS EN 206.

A number of solutions exist. These are given in good faith and it must be stressed that these are suggestions and not recommendations.

- Repair the spalled areas and install cathodic protection to stop the corrosion potential. This option will not help the aesthetic appearance of the structure but will maintain its integrity. Joints between the panels and the columns will also have to be cleaned and resealed to prevent any further ingress of chlorides.
- Install cathodic protection, repair any defects and construct a facia over the concrete.

AUTHORITY

Authored and Certified for Issue

Digitally signed by Bill Bayston. Signature can be verified or Original documents viewed at Laboratory Services on request

Digitally signed by Bill Bayston
Location: Laboratory Services
Date: 2007.01.05 15:03:10 Z

Bill Bayston
Acting Group Leader (Laboratory Services)

Date 5 January, 2007

SCHEDULE OF TESTS

Middlesbrough Council

Testing

	Test Method	
Half Cell Potential	ASTM C 876 -99	UKAS Accredited (0678)
Visual and Delamination Condition Survey	Series 2800 Supplement Notes For Guidance - Specification for Highway Works	Not UKAS Accredited
Cover Meter Survey	Doc In House by Ferroscan	Not UKAS Accredited

Sampling

	Test Method	
Dust Sample for Analysis	TRRL Contractor Report 32	UKAS Accredited (0678)

Tests Performed by Sub-Contractor

Construction Materials Testing Limited

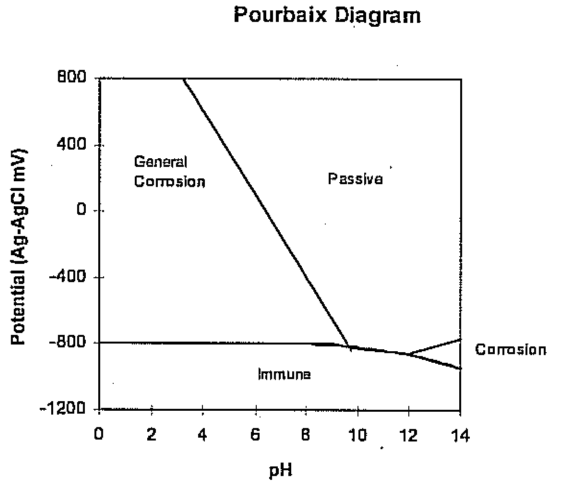
Testing

	Test Method	
Chloride Content	BS 1881:Part 124:1988	UKAS Accredited(0529)

NOTE : The cement content of the concrete was assumed to be 14%.

NOTES

Potential Mapping by Half Cell Survey
Pourbaix Diagram



NOTE : The scale is for a Silver-Silver Chlorate Electrode

The pH of new (fresh) concrete, due to the presence of Calcium Hydroxide, is between 10 - 13. According to the Pourbaix diagram (above) this would indicate that the steel reinforcement is protected from corrosion by the alkaline environment.

Over time the pH of the concrete changes as a result of environmental influences such as the penetration of aggressive gases (SO_2, SO_3), chlorides, moisture and changes in temperature. The effect of these influences is that the concrete no longer provides complete protection for the steel against corrosion due to the reduction in pH (i.e. less alkaline).

Very often the steel reinforcement in concrete corrodes due to the presence of water - an electro-chemical reaction. Iron, in an anodic area of the steel dissolves and the electrons drift to a cathodic area and react with oxygen and water thus forming a ferrous oxide - rust. Through this process of rusting poles of differing electrical potential are created at the steel. Between these poles an electrical filed is created with lines of equal potential.

The steel in the concrete acts as an electrode, and the concrete itself, with its moisture, as an electrolyte - like one half of a battery.

In order to measure these potentials another half battery is introduced in the form of a copper-copper sulphate reference electrode. When this reference electrode is pressed onto the surface of the concrete a complete battery is created with a potential voltage which can be measured and therefore gives an indication of areas where the steel is corroded.

In order to attain good electrical connection a section of the steel reinforcement is exposed and a direct connection made onto this steel. Regular readings are then taken either over the whole of the concrete surface or a test panel area. Typically a 1.0 by 1.0 m grid will be used for large exposed areas such as a bridge deck and a 0.5 by 0.5m grid for smaller areas such as test panels on abutments etc. A typical test panel would measure 2.0m by 1.0m and would be orientated to suit the exposure conditions.

The results of each test are measured in mV (milliVolts).

To aid interpretation tabulated values may be processed to produce lines of equal potential (contour lines) which then readily impart the survey results.

Visual Survey

The visual survey is performed by an experienced person to identify potential defects within the visible concrete surface. These are then brought to the attention of the Client engineer or identified for further investigation.

Hammer Survey

A hammer survey consists of striking the exposed concrete with a metal headed hammer (~ 3.5kg). The resultant sound is then compared to its predecessors to detect any aural difference which could identify potential defects.

This test is performed by an experienced person as the result is subjective to that operative. Similarly the test is performed by that individual over the complete exposed surface in order to gain repeatability and reproducibility of the striking action.

Sampling by Rotary Drilling

Rotary drilling for sampling of concrete is normally carried out using a hand held electric powered rotary hammer drill employing a tungsten carbide tipped drill. The resulting dust is, where applicable, collected as an individual sample and transferred into a plastic bag, sealed and labelled for analysis.

The rotary drill incorporates a positive dust collection system which utilises a vacuum to contain and collect dust risings which are collected for analysis.

Sufficient dust samples were taken in 25mm increments, at each location, to the depth of the reinforcement. The initial 5mm was discarded.

The location of each sample was determined by the Client Engineer having viewed the results of the half cell potential tests. (As a guide, readings more negative than -250 mV, in areas of change, were sampled.)

Ferroscan

Cover's quoted are a range found in each 600mm square inspected. Each scan picture has a different point high lighted. At that point the depth of cover has been determined and where possible the diameter of the reinforcement has been determined.

Diameter or depth of coverage cannot be determined at some points. There can be a number of reasons for this.

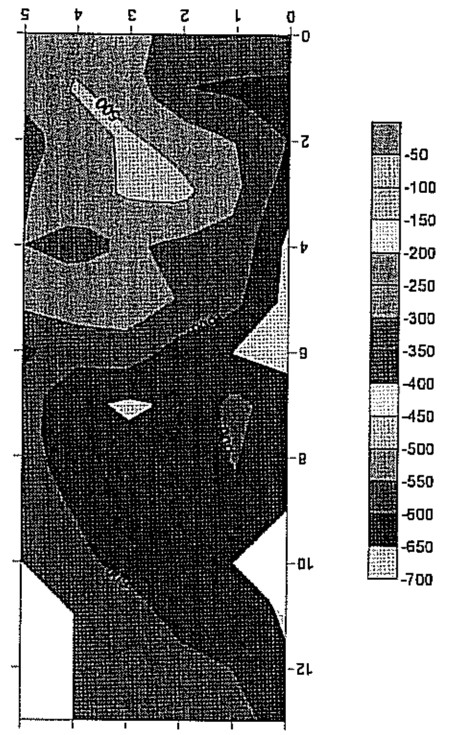
- The position of the reinforcing bars is beyond the measured range.
- Objects made of other metals or with other magnetic properties are present.
- The measuring point is too close to the edge of the scanned area and inadequate data is available for determining the required information.
- Two reinforcing bars are located too close together. Asymmetrical positioning of the bars could lead to incorrect evaluation and, accordingly, no values are displayed.
- The reinforcing bars have an unusual shape, which cannot be evaluated by the algorithm employed.
- The measuring signal is distorted due to vibration caused by a rough surface or some other source interference. The algorithm ceases to function when interference is excessive.

Half Cell Potential Readings

Grid Size – 0.5m centres on panels and 0.3m centres on columns. Both start 0.1m in from left hand edge of member

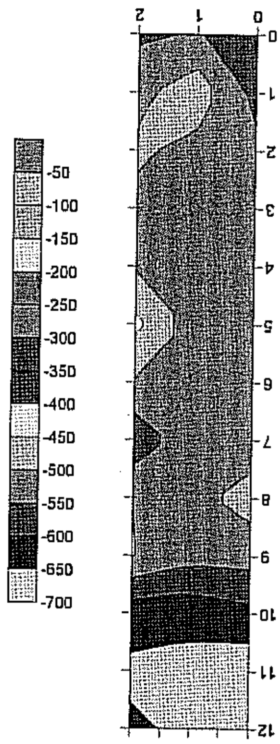
Half Cell Potential
Contour Map and Half Cell Values for Panel 1

Panel 1



-521	-523	-538	-567	-554	-547
-524	-494	-537	-599	-610	-618
-574	-519	-493	-520	-551	-601
-554	-519	-493	-487	-537	-632
-549	-573	-544	-561	-572	-663
-531	-516	-519	-554	-580	-666
-608	-582	-569	-622	-654	-660
-582	-637	-658	-643	-581	-635
-573	-638	-633	-626	-596	-635
-583	-602	-636	-636	-611	-612
	-577	-587	-616	-604	-634
	-567	-568	-620	-612	-658
	-565	-567	-578	-600	-641
	-584	-563	-568	-572	-627

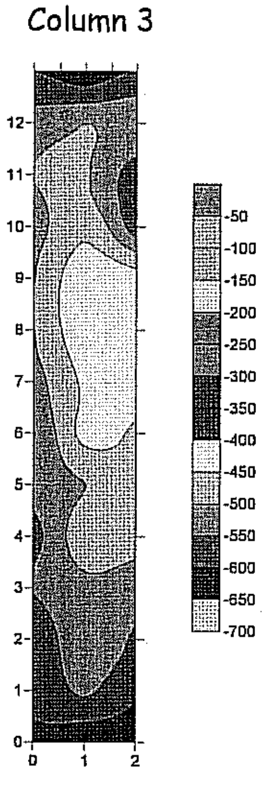
Half Cell Potential
Contour Map and Half Cell Values for Column 2



Column 2

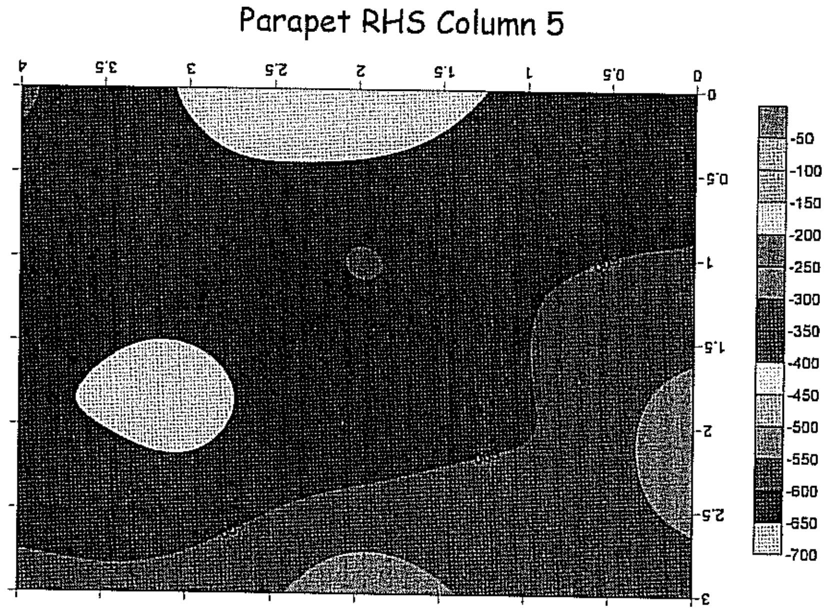
-599	-545	-559
-567	-469	-513
-537	-517	-492
-546	-514	-512
-551	-509	-506
-532	-516	-438
-535	-524	-504
-527	-517	-590
-478	-516	-500
-531	-533	-498
-615	-636	-630
-684	-665	-659
-700	-659	-642

Half Cell Potential
Contour Map and Half Cell Values for Column 3



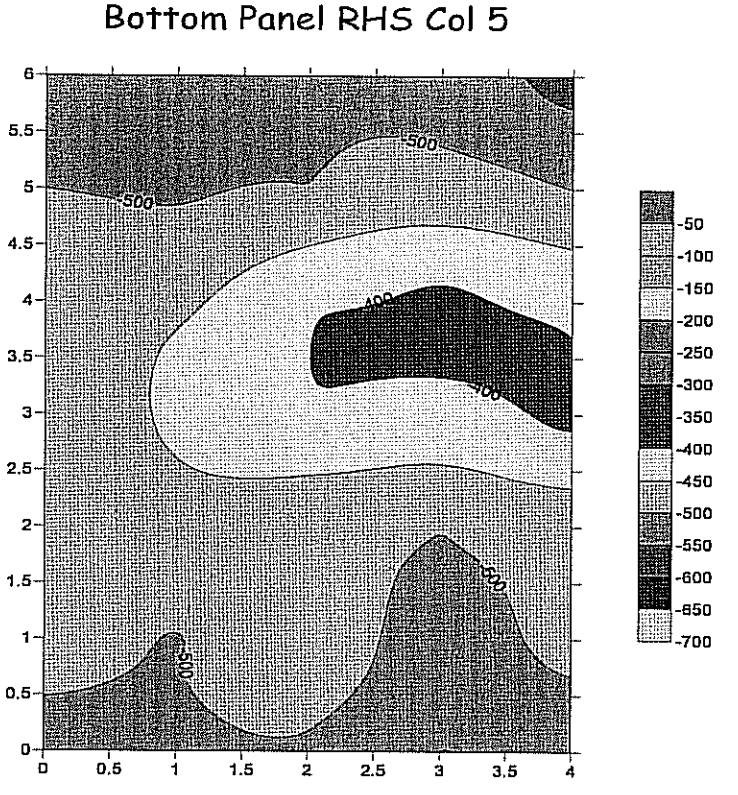
-646	-404	-521
-600	-646	-596
-523	-497	-496
-496	-495	-589
-527	-453	-586
-504	-404	-424
-502	-407	-417
-522	-441	-433
-556	-424	459
-537	-504	-462
-571	-460	-474
-545	-511	-540
-602	-505	-558
-586	-536	-593
-612	-635	-627

Half Cell Potential
Contour Map and Half Cell Values for
Parapet Wall above and right Column 5



-641	-692	-655	-593	-558
-597	-605	-593	-637	-619
-517	-605	-637	-664	-648
-564	-565	-513	-582	-581

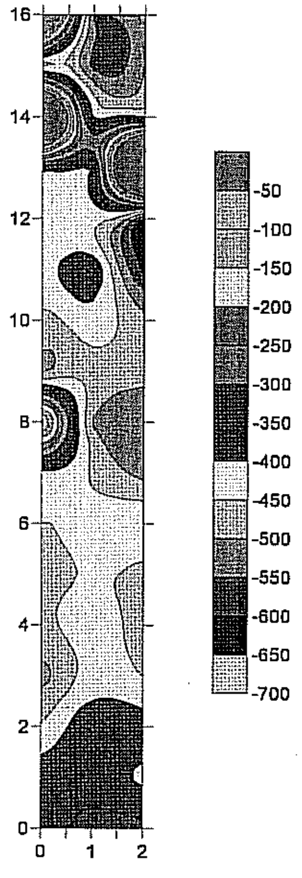
Half Cell Potential
Contour Map and Half Cell Values for
Bottom Panel to RHS of Column 5



-519	-511	-505	-551	-542
-477	-503	-452	-530	-474
-468	-464	-486	-499	-400
-490	-441	-403	-420	-386
-462	-460	-404	-387	-411
-500	-509	-499	-479	-501
-539	-533	-507	-519	-571

Half Cell Potential
Contour Map and Half Cell Values for
Column 23

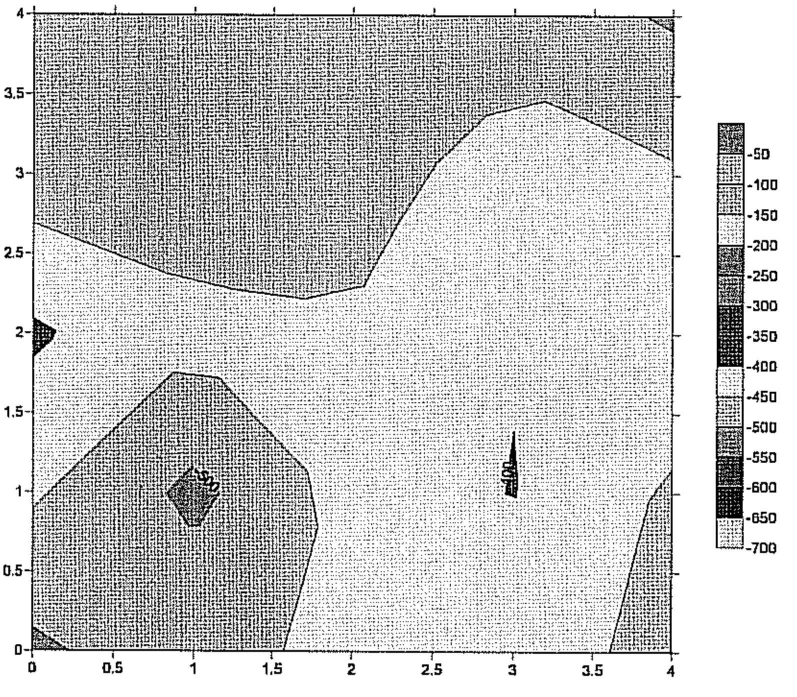
Column 23



-369	-388	-413
-399	-318	-338
-448	-342	-375
-525	-432	-453
-461	-408	-475
-451	-422	-398
-468	-448	-469
-418	-457	-517
-493	-514	-546
-527	-458	-476
-473	-406	-489
-412	-336	-614
-426	-437	-660
-393	-409	832
517	-421	-427
-497	-566	-495
-552	-560	-481

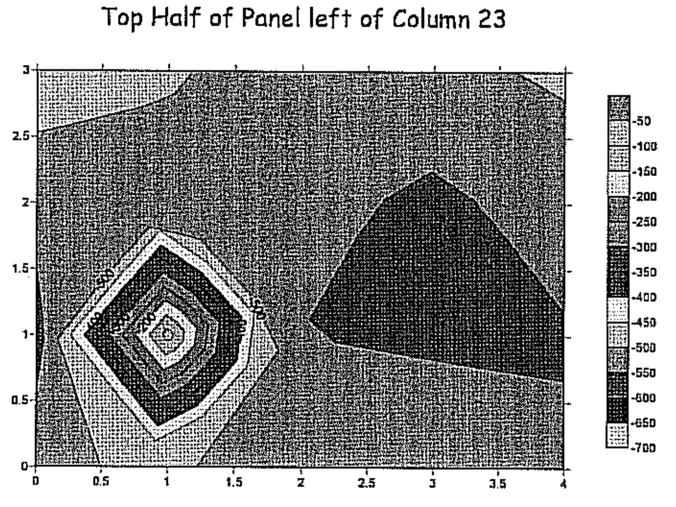
Half Cell Potential
Contour Map and Half Cell Values for
Parapet Wall left of Column 23

Parapet Wall left of Column 23



-510	-466	-438	-436	-459
-443	-512	-438	-398	-458
-392	-441	-445	-403	-405
-476	-470	-472	-423	-444
-487	-470	-499	-473	-506

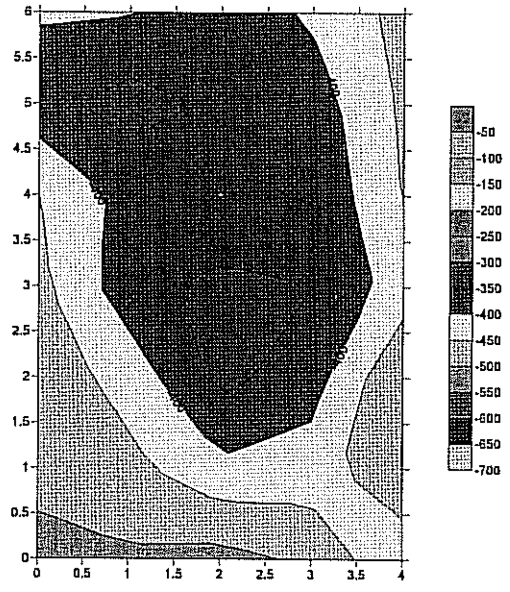
Half Cell Potential
Contour Map and Half Cell Values for
Top half of first Panel left of Column 23



-507	-493	-526	-527	-540
-583	-78	-550	-555	-555
-519	-514	-533	-563	-526
-483	-496	-518	-512	-493

Half Cell Potential
Contour Map and Half Cell Values for
Middle Panel left of Column 23

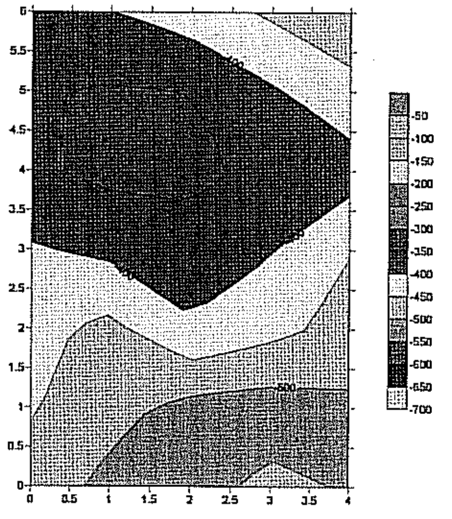
Middle Panel Left of Column 23



-512	-507	-519	-490	-408
-489	-464	-410	-424	-501
-479	-431	-335	-378	-499
-462	-370	-334	-350	-424
-452	-382	-401	-358	-453
-367	-330	-359	-375	-459
-406	-403	-369	-408	-467

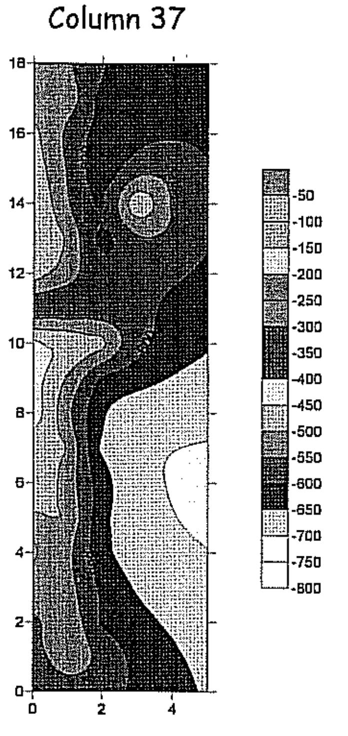
Half Cell Potential
Contour Map and Half Cell Values for
Lower Panel left of Column 23

Lower Panel Left of Column 23



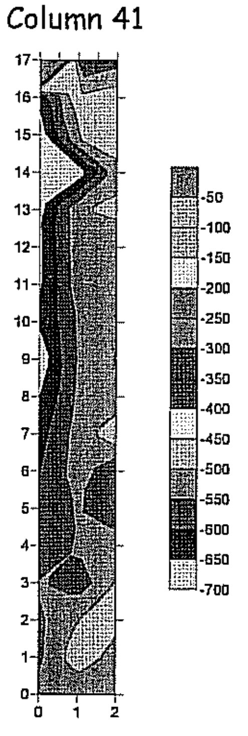
-472	-513	-518	-488	-504
-445	-483	-516	-524	-510
-435	-463	-406	-435	-469
-404	-388	-372	-397	-448
-357	-337	-336	-366	-378
-353	-346	-351	-394	-432
-388	-399	-424	-458	-489

Half Cell Potential
Contour Map and Half Cell Values for
Column 37



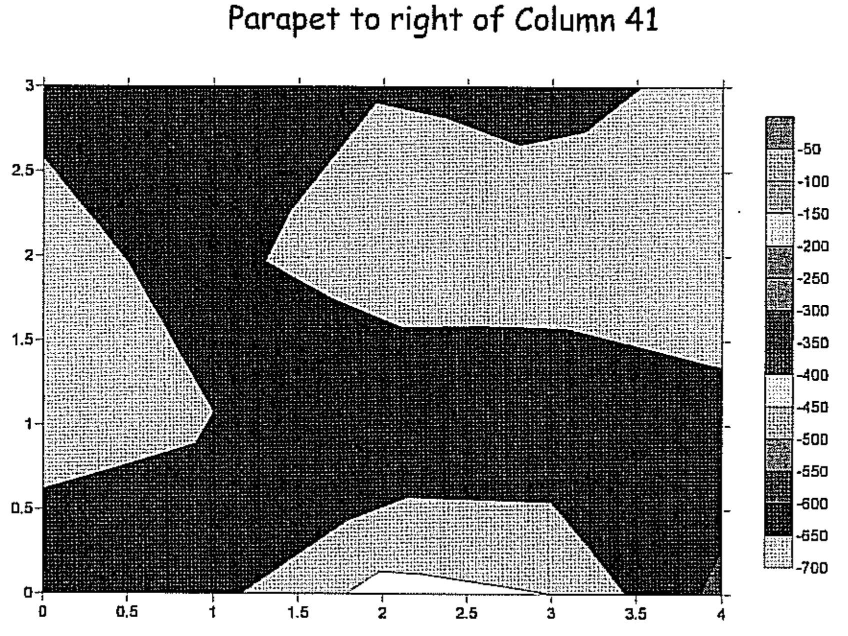
-613	-572	-582
-569	-516	-561
-567	-514	-607
-505	-529	-610
-510	-501	-637
-497	-536	-637
-421	-539	-645
-479	-499	-620
-434	-509	-611
-435	-595	-594
-471	-519	-594
-454	-506	-619
-454	-547	-607
-444	-560	-589
-474	-555	-640
-489	-563	-621
-527	-519	-617
-499	-545	-597

Half Cell Potential
Contour Map and Half Cell Values for Column 41



-536	-547	-549
-561	-463	-521
-559	-501	-483
-545	-580	-499
-604	-546	-511
-589	-547	-602
-603	-524	-602
-618	-529	-457
-652	-541	-539
-687	-544	-497
-643	-545	-513
-664	-517	-521
-658	-523	-539
-656	-504	-487
-671	-683	-520
-679	-482	-463
-636	-483	-469
314	-595	-570

Half Cell Potential
Contour Map and Half Cell Values for
Parapet to Top Panel right of Column 41

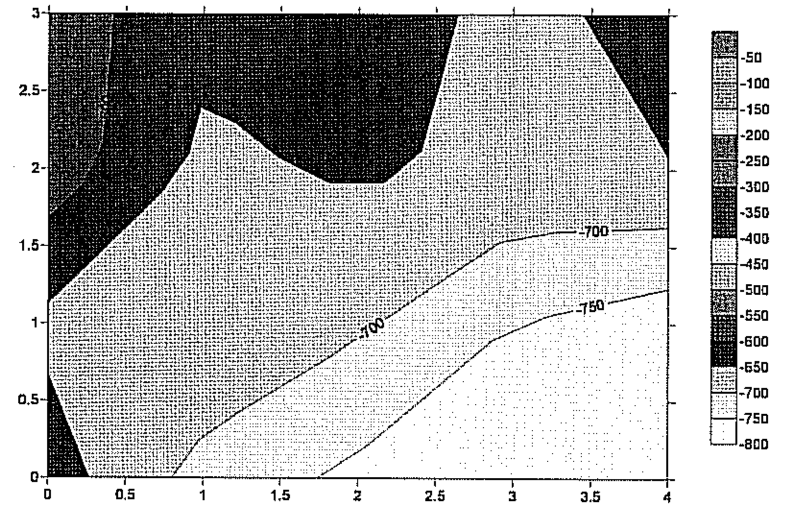


-619	-637	-717	-700	-586
-669	-651	-600	-608	-638
-661	-638	-686	-679	-673
-642	-649	-648	-630	-668

Half Cell Potential
Contour Map and Half Cell Values for
Top Panel right of Column 41

f

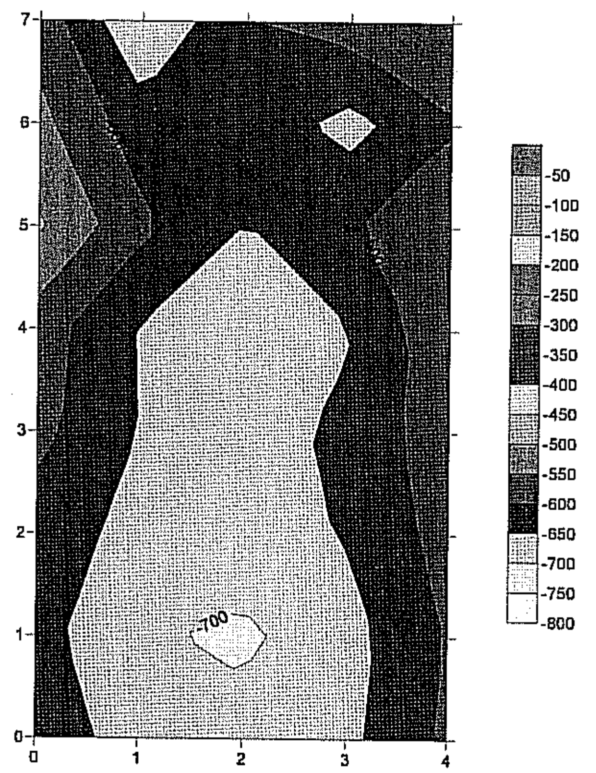
Top Panel right of Column 41



-625	-719	-761	-785	-800
-662	-651	-693	-750	-779
-570	-661	-642	-664	-653
-573	-637	-602	-677	-616

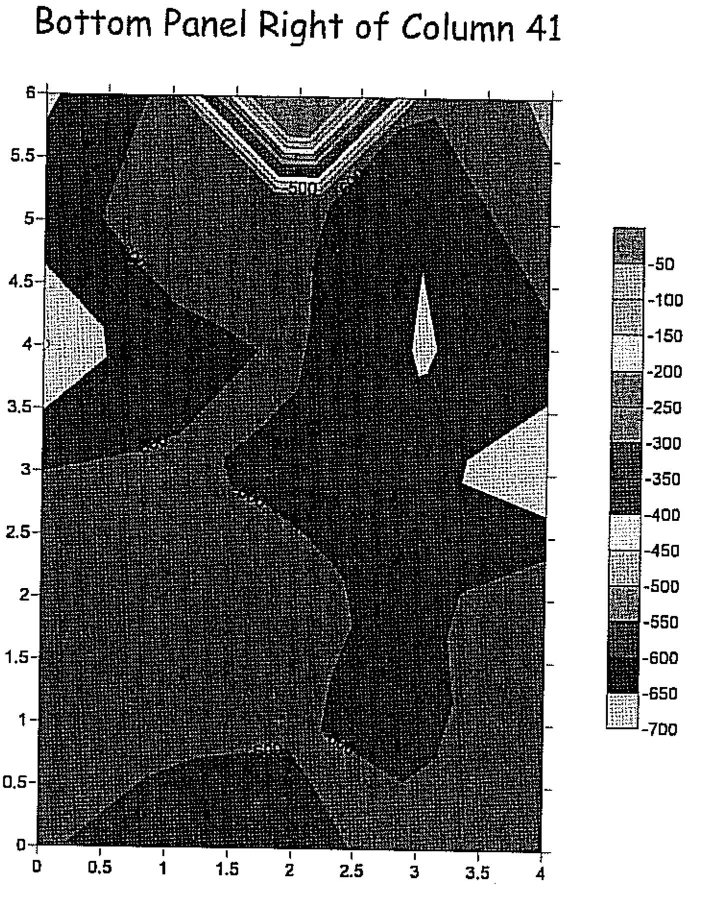
Half Cell Potential
Contour Map and Half Cell Values for
Centre Panel right of Column 41

Centre Panel Right of Column 41



-600	-684	-684	-663	-591
-632	-693	-709	-670	-597
-626	-664	-676	-646	-581
-584	-651	-661	-644	-561
-575	-653	-689	-652	-566
-494	-588	-653	-603	-573
-537	-628	-622	-666	-603
-571	-701	-601	-579	-574

**Half Cell Potential
Contour Map and Half Cell Values for
Bottom Panel right of Column 41**



-658	-586	299	-598	-538
-620	-575	-592	-647	-565
-705	-614	-594	-655	-614
-600	-596	-609	-638	-698
-567	-571	-585	-612	-550
-564	-576	-596	-619	-555
-588	-649	-616	-582	-587

CHOLRIDE CONTENT DETERMINATION

Chloride Contents

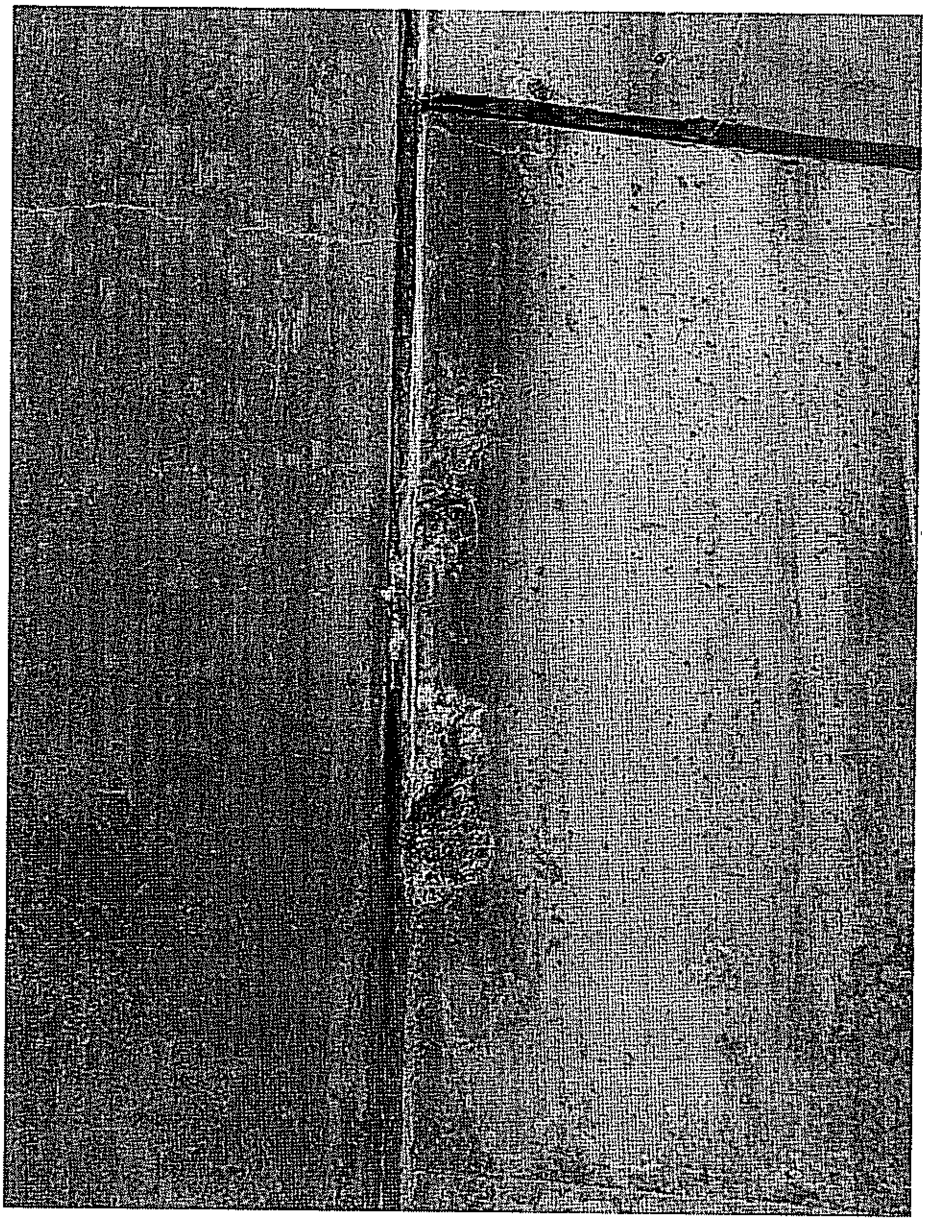
In the absence of concrete batching records, a cement content of 14% has been applied to the results below. The values quoted assuming 14% cement content should be used when assessing chloride potential.

Sample Ref	Location	Depth (mm)	% Chloride by mass of Sample	% Chloride by mass of Cement (Assuming 14%)
06S0708	Panel 1 Position 1	5 - 30mm	0.255	1.82
06S0709		30- 55mm	0.205	1.46
06S0710		55 - 80mm	0.128	0.91
06S0711	Panel 1 Position 2	5 - 30mm	0.163	1.16
06S0712		30- 55mm	0.184	1.32
06S0713		55 - 80mm	0.163	1.16
06S0714	Column 2 Position 1	5 - 30mm	0.113	0.81
06S0715		30- 55mm	0.085	0.61
06S0716		55 - 80mm	0.198	1.41
06S0717	Column 2 Position 2	5 - 30mm	0.085	0.61
06S0718		30- 55mm	0.057	0.40
06S0719		55 - 80mm	0.043	0.30
06S0720	Column 5 Position 1	5 - 30mm	0.092	0.66
06S0721		30- 55mm	0.071	0.50
06S0722		55 - 80mm	0.049	0.35
06S0723	Column 5 position 2	5 - 30mm	0.156	1.11
06S0724		30- 55mm	0.220	1.57
06S0725		55 - 80mm	0.099	0.71
06S0726	Panel Right of Column 5 Position 1	5 - 30mm	0.468	3.34
06S0727		30- 55mm	0.374	2.67
06S0728		55 - 80mm	0.276	1.97
06S0729	Panel Right of Column 5 Position 2	5 - 30mm	0.502	3.58
06S0730		30- 55mm	0.425	3.04
06S0731		55 - 80mm	0.184	1.31
06S0744	Column 23 Position 1	5 - 30mm	0.028	0.20
06S0745		30- 55mm	0.014	0.10
06S0746		55 - 80mm	0.007	0.05
06S0732	Panel Left of Column 23 Position 1	5 - 30mm	0.438	3.13
06S0733		30- 55mm	0.432	3.09
06S0734		55 - 80mm	0.241	1.72
06S0735	Panel Left of Column 23 Position 2	5 - 30mm	0.297	2.12
06S0736		30- 55mm	0.156	1.11
06S0737		55 - 80mm	0.099	0.71
06S0741	Parapet Left of Column 23 Position 1	5 - 30mm	0.291	2.08
06S0742		30- 55mm	0.551	3.94
06S0743		55 - 80mm	0.206	1.47

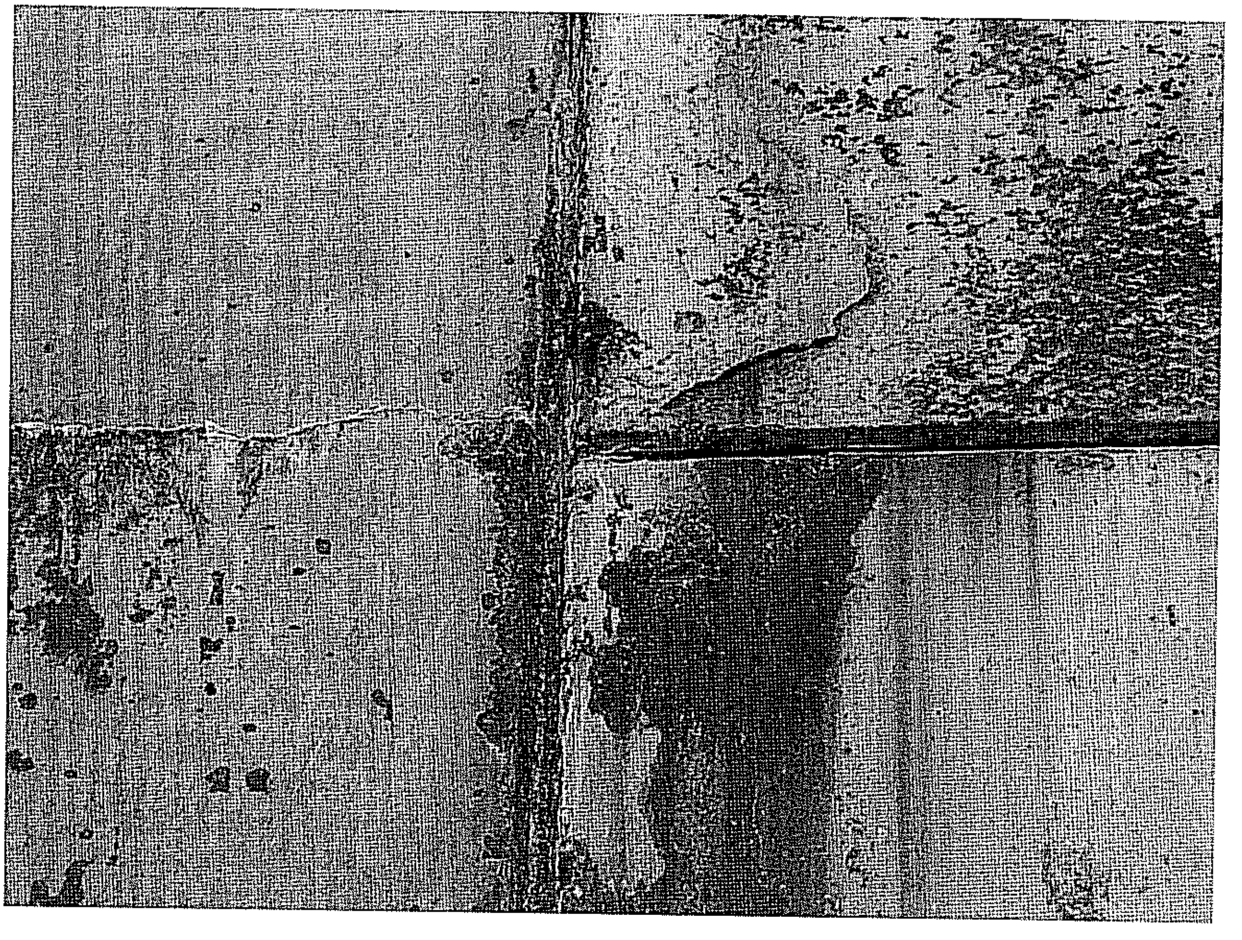
Sample Ref	Location	Depth (mm)	% Chloride by mass of Sample	% Chloride by mass of Cement (Assuming 14%)
06S0744	Column 23 Position 1	5 - 30mm	0.028	0.20
06S0745		30- 55mm	0.014	0.10
06S0746		55 - 80mm	0.007	0.05
06S0747	Column 23 Position 2	5 - 30mm	0.213	1.52
06S0748		30- 55mm	0.198	1.41
06S0749		55 - 80mm	0.064	0.45
06S0750	Column 37 Position 1	5 - 30mm	0.035	0.25
06S0751		30- 55mm	0.014	0.10
06S0752		55 - 80mm	0.007	0.05
06S0753	Column 37 Position 2	5 - 30mm	0.121	0.86
06S0754		30- 55mm	0.099	0.71
06S0755		55 - 80mm	0.043	0.30
06S0756	Column 41 Position 1	5 - 30mm	0.028	0.20
06S0757		30- 55mm	0.014	0.10
06S0758		55 - 80mm	0.014	0.10
06S0759	Column 41 Position 2	5 - 30mm	0.028	0.20
06S0760		30- 55mm	0.021	0.15
06S0761		55 - 80mm	0.014	0.10
06S0762	Panel Right of Column 41 Position 1	5 - 30mm	0.268	1.92
06S0763		30- 55mm	0.283	2.02
06S0764		55 - 80mm	0.184	1.31
06S0765	Panel Right of Column 41 Position 2	5 - 30mm	0.092	0.66
06S0766		30- 55mm	0.092	0.66
06S0767		55 - 80mm	0.071	0.51

Photographic Records

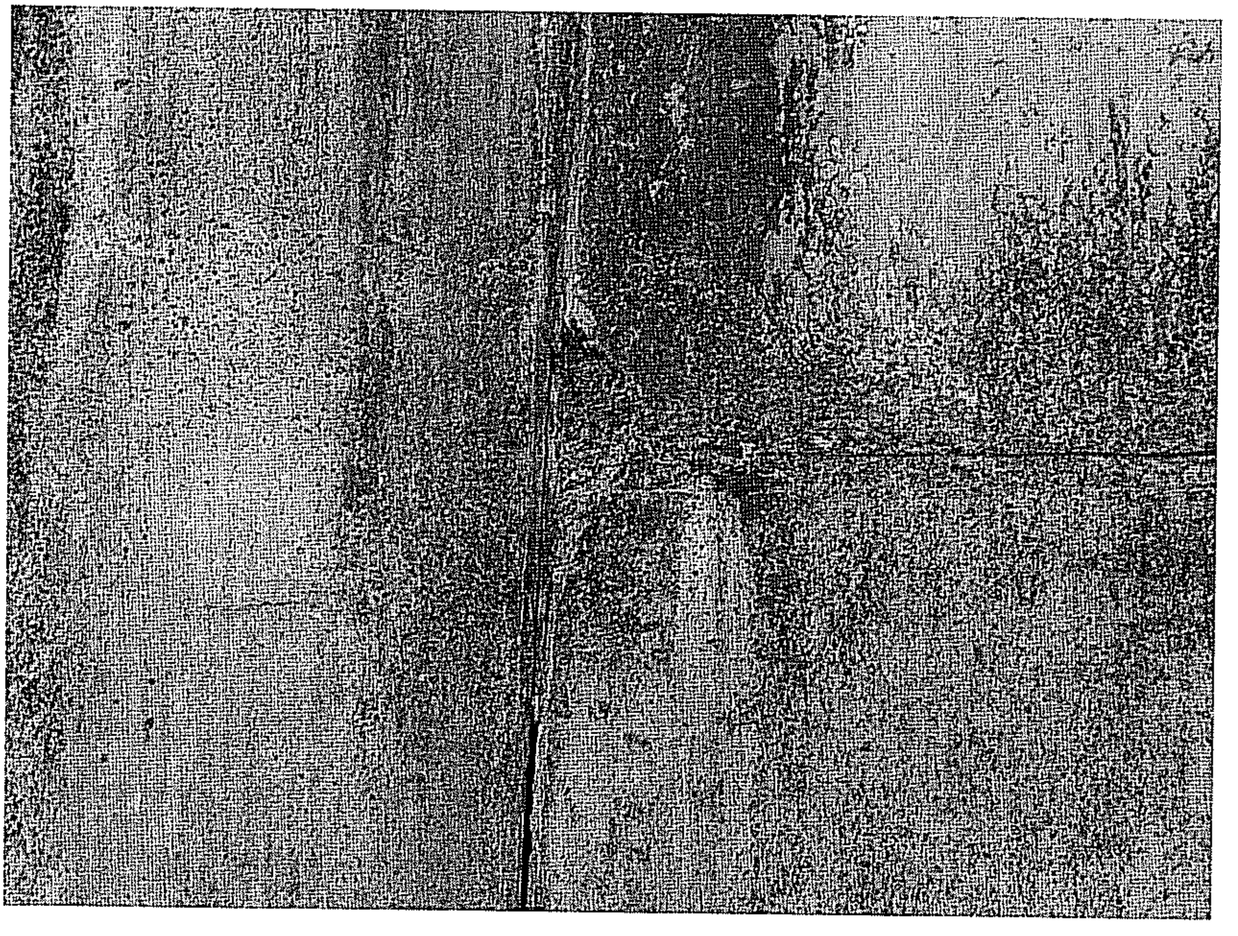
Areas of spalling, cracking and rust staining from joints



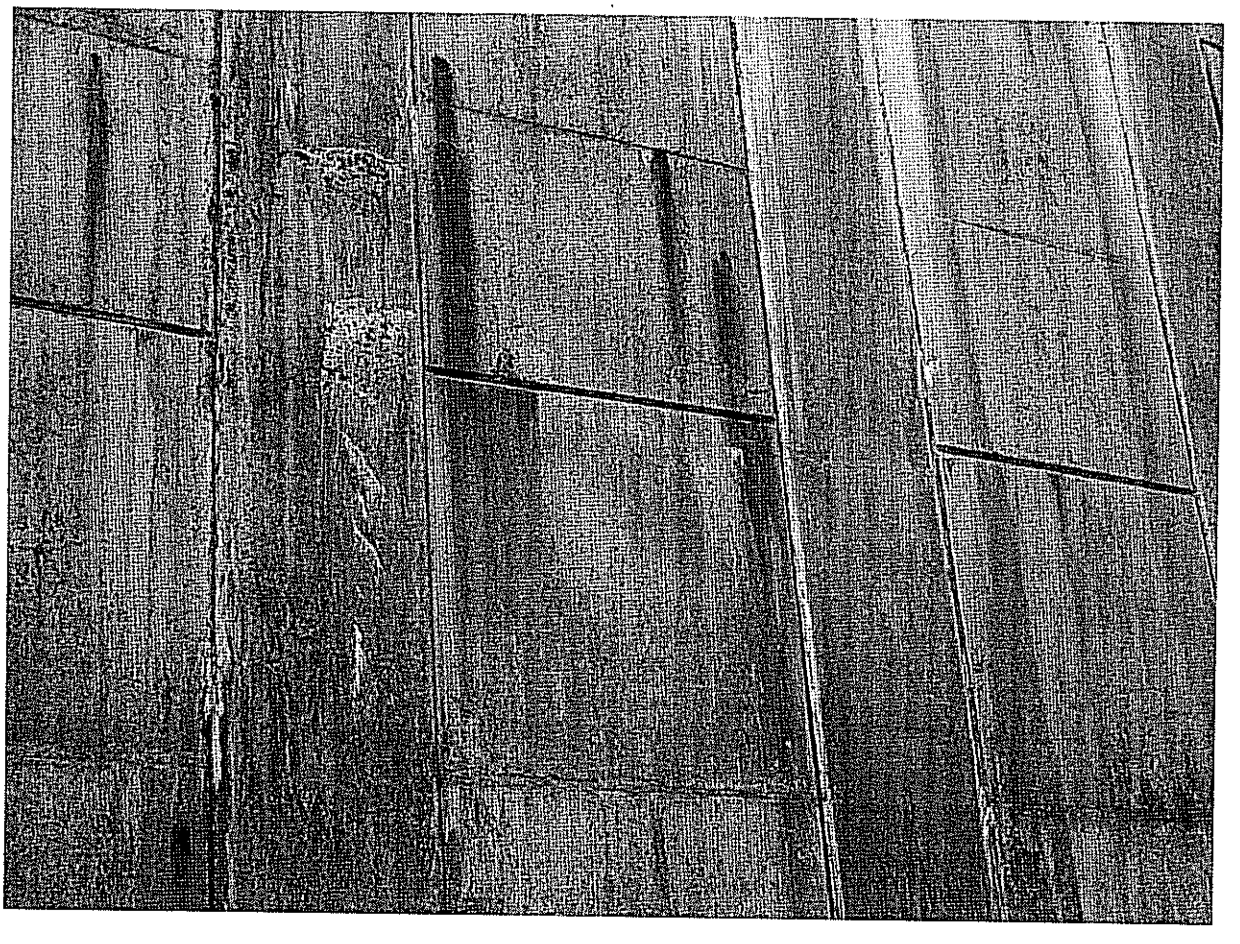
Spalling of the surface and rust staining



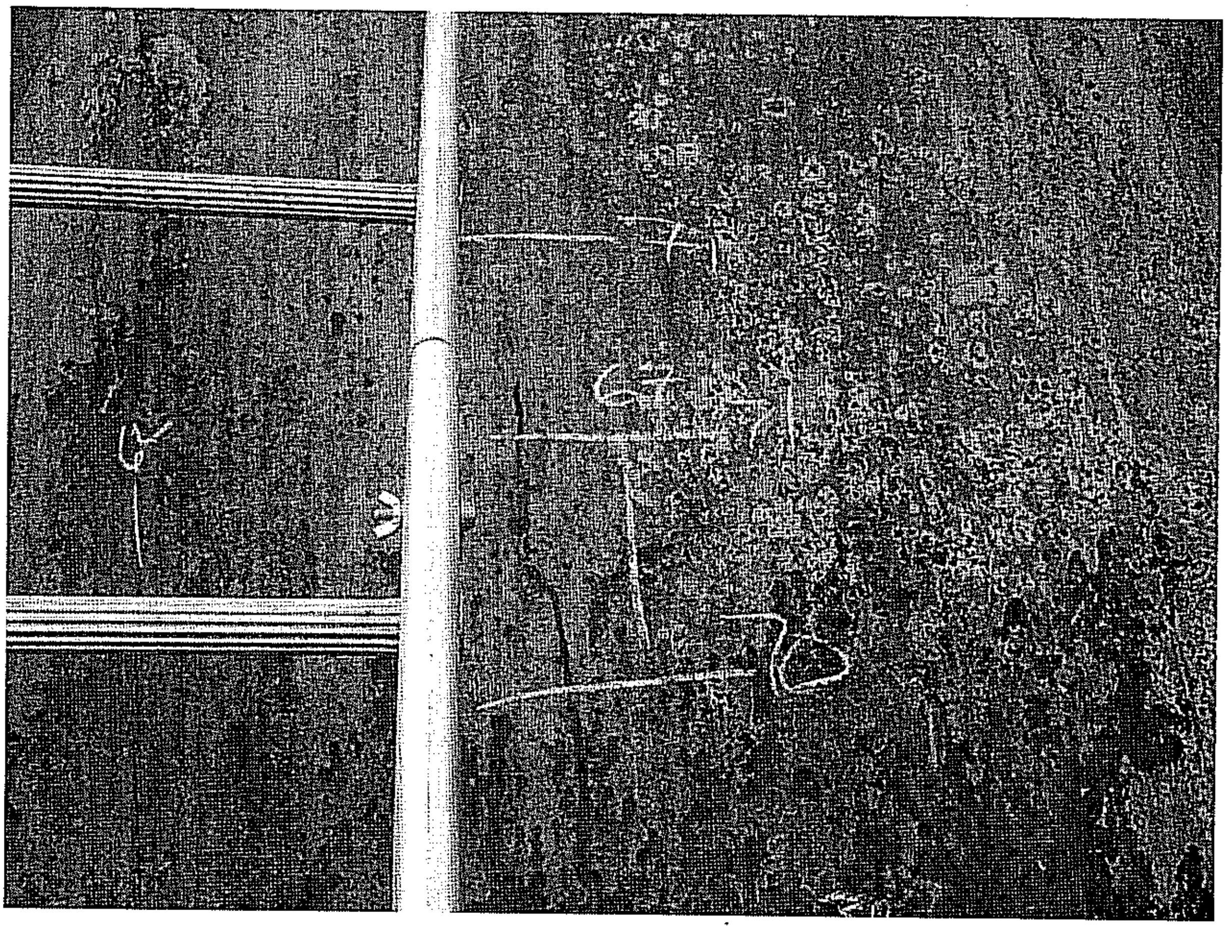
Minor Spalling and iron stone staining



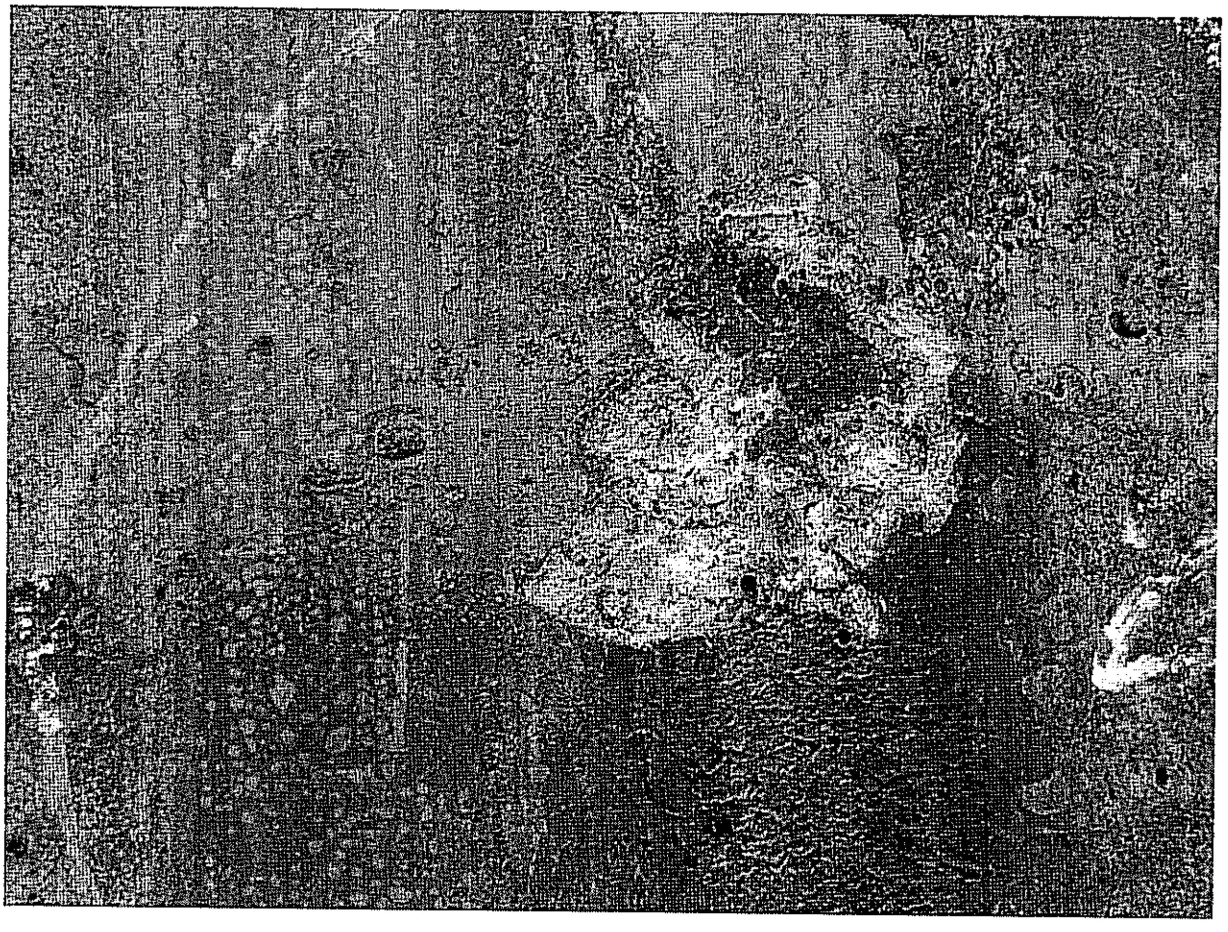
This staining is generally all from iron inclusions or tie wire close to the surface of the concrete



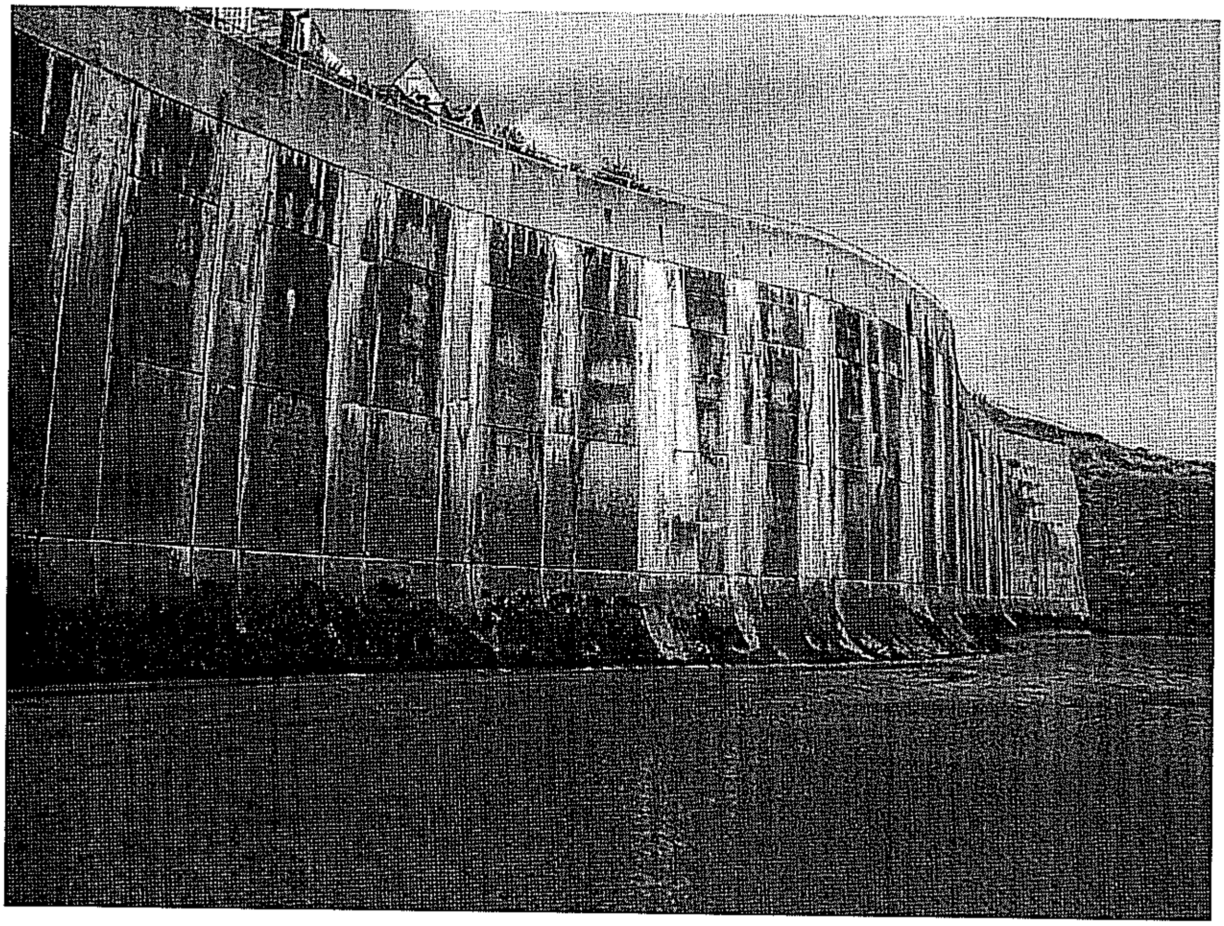
Location and reinforcement depth



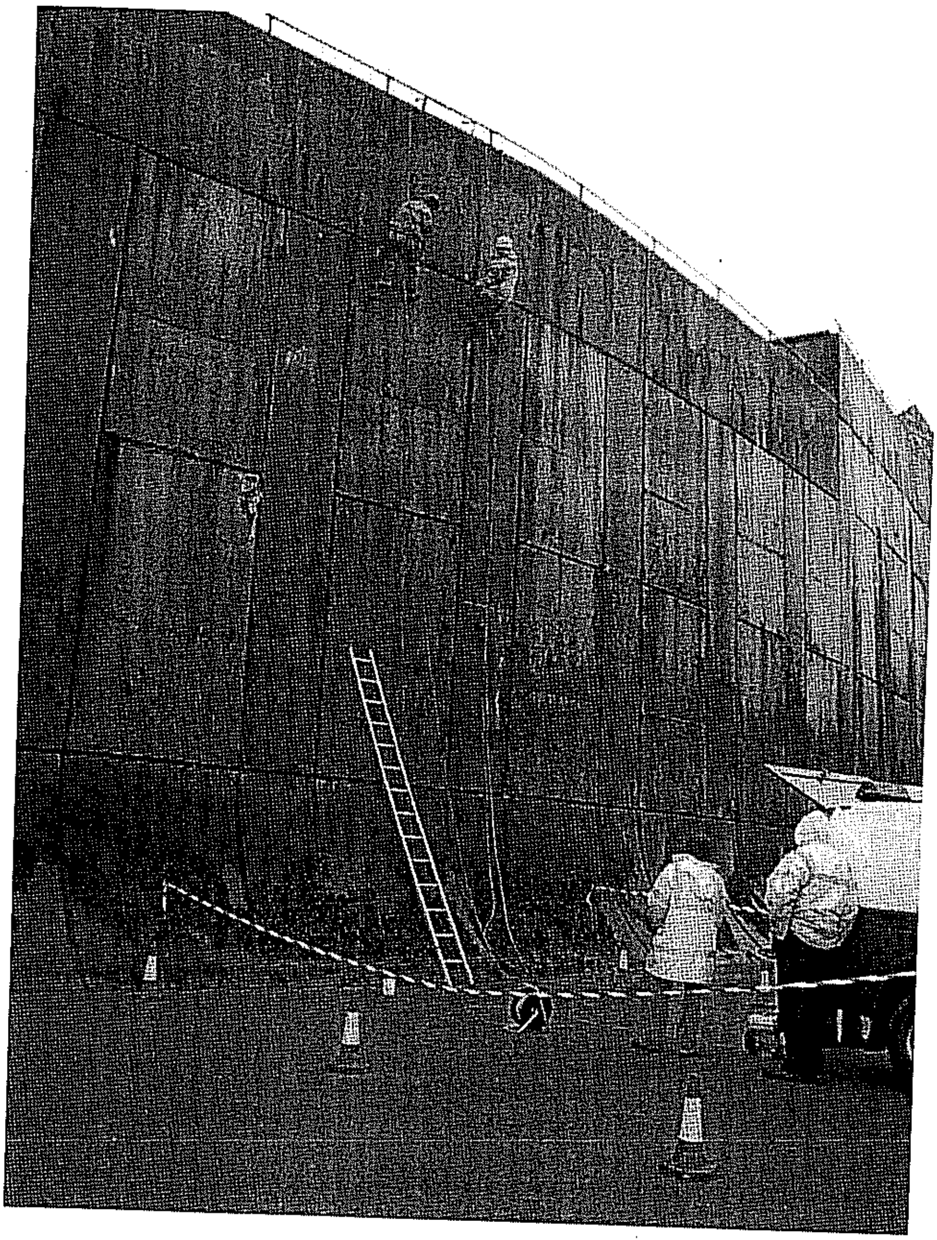
Another example of iron inclusions within the aggregate

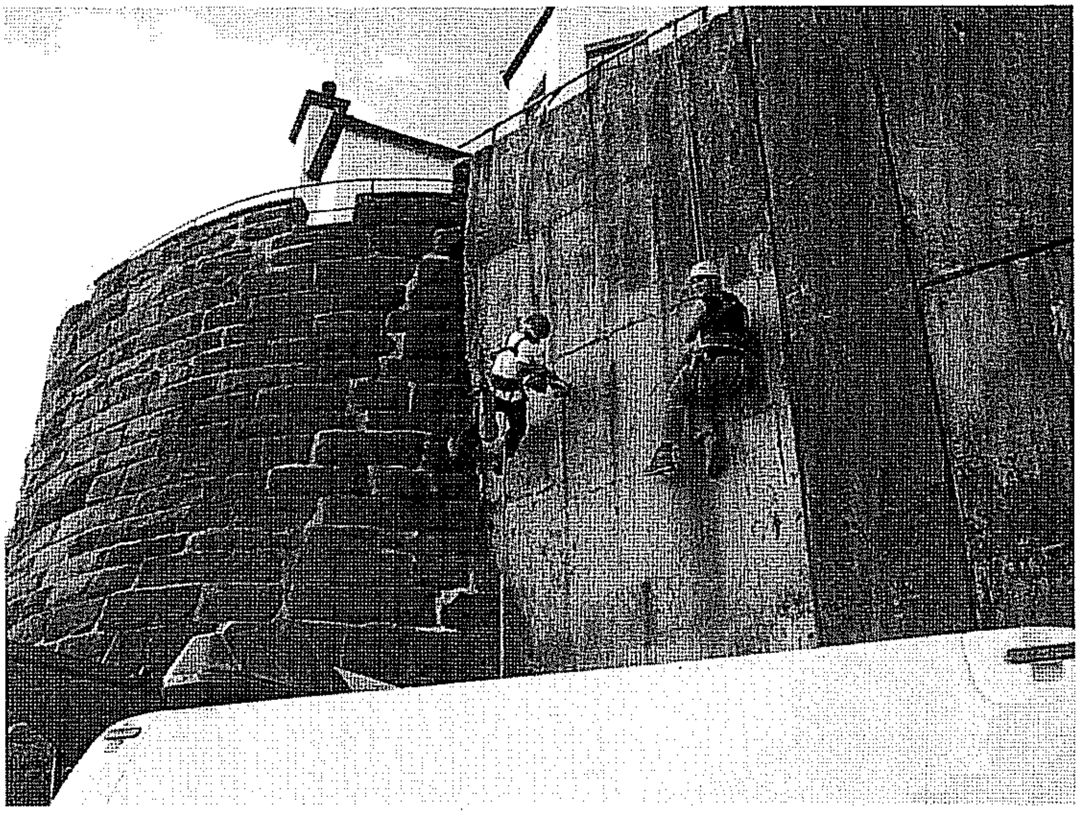


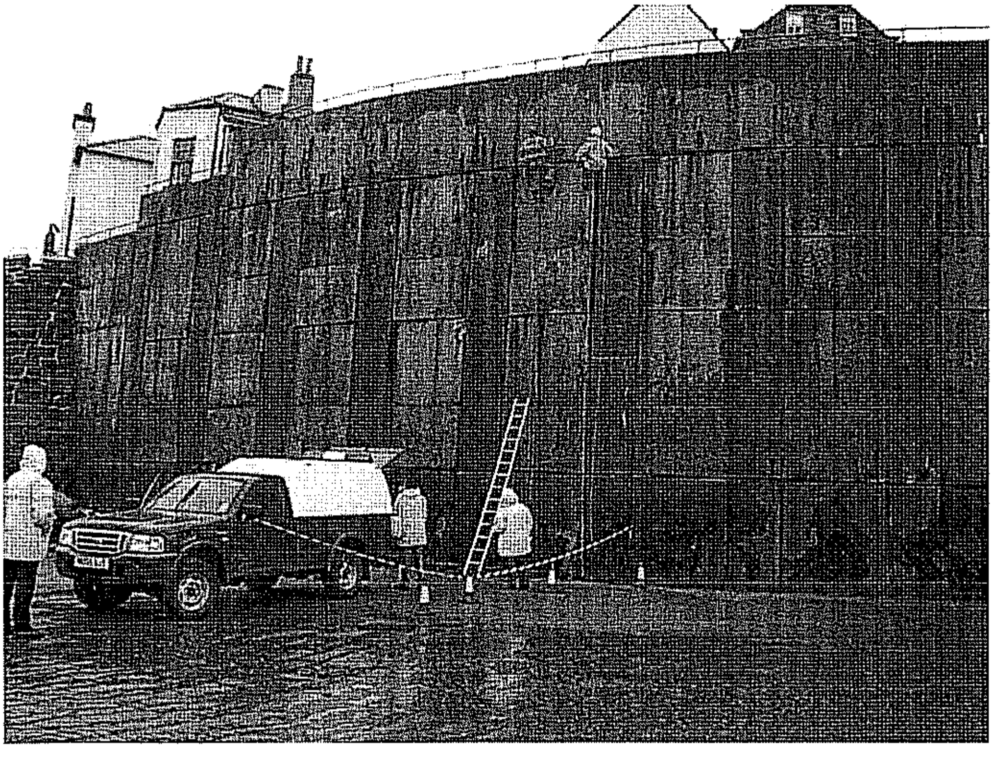
Calcium staining from the parapet wall. Leaking joint between the parapet and panel.



Assailers and Laboratory Staff testing wall



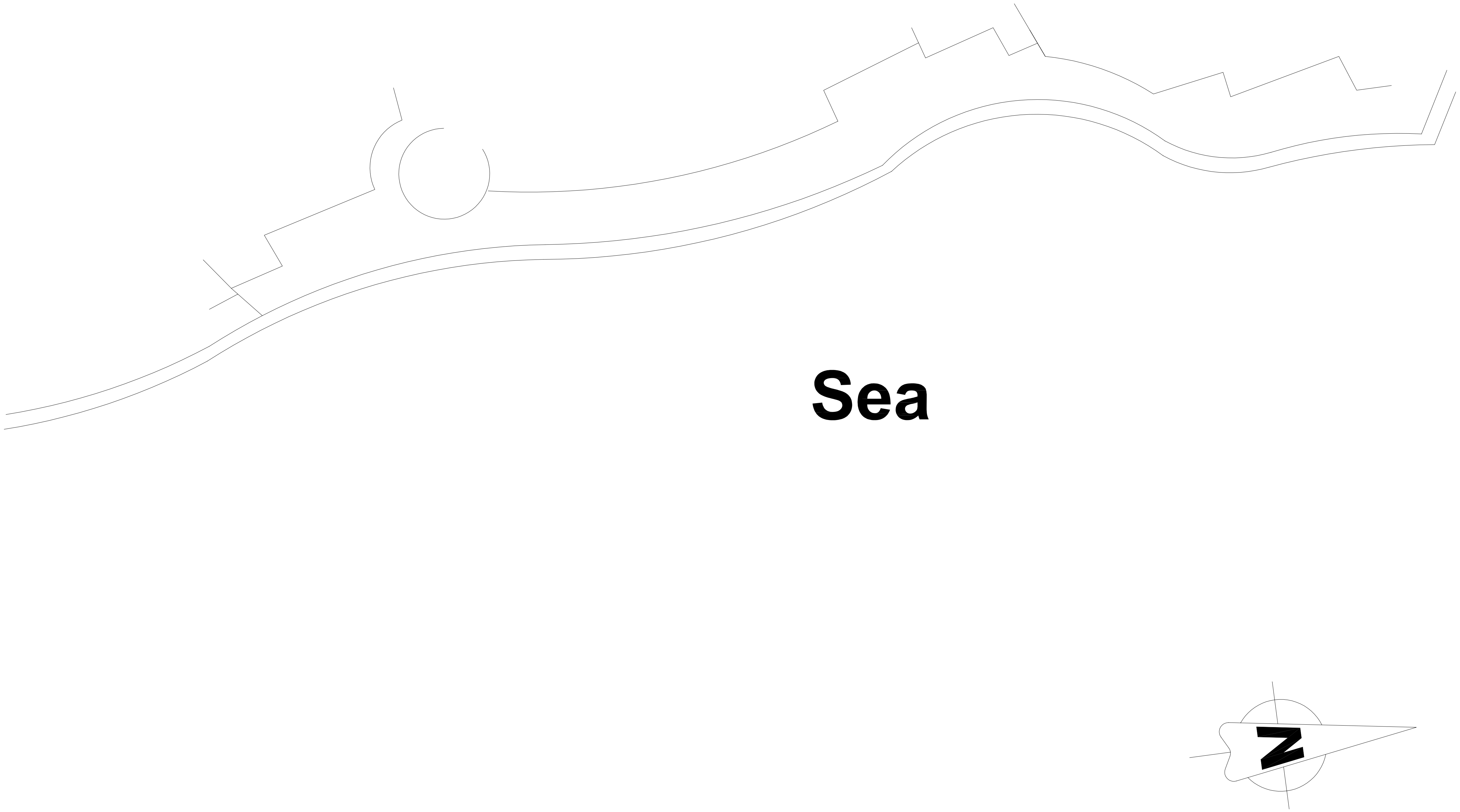




9. APPENDIX B: CRL DRAWINGS

9.1 DRAWINGS - EAST FACE / MAIN WALL

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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W: www.concrete-repairs.co.uk

Client: Scarborough Borough Council
Town Hall
St. Nicolas Street, Scarborough
North Yorkshire, YO11 2HG

Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Key Plan

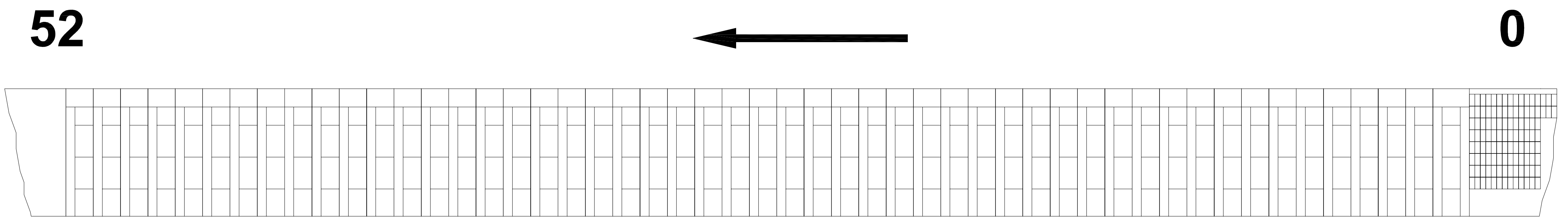
Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07

Drawing Number: SUR07603/27 Revision

Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- Surface Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Rust Staining
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

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Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / East Face
Test Areas Arrangement

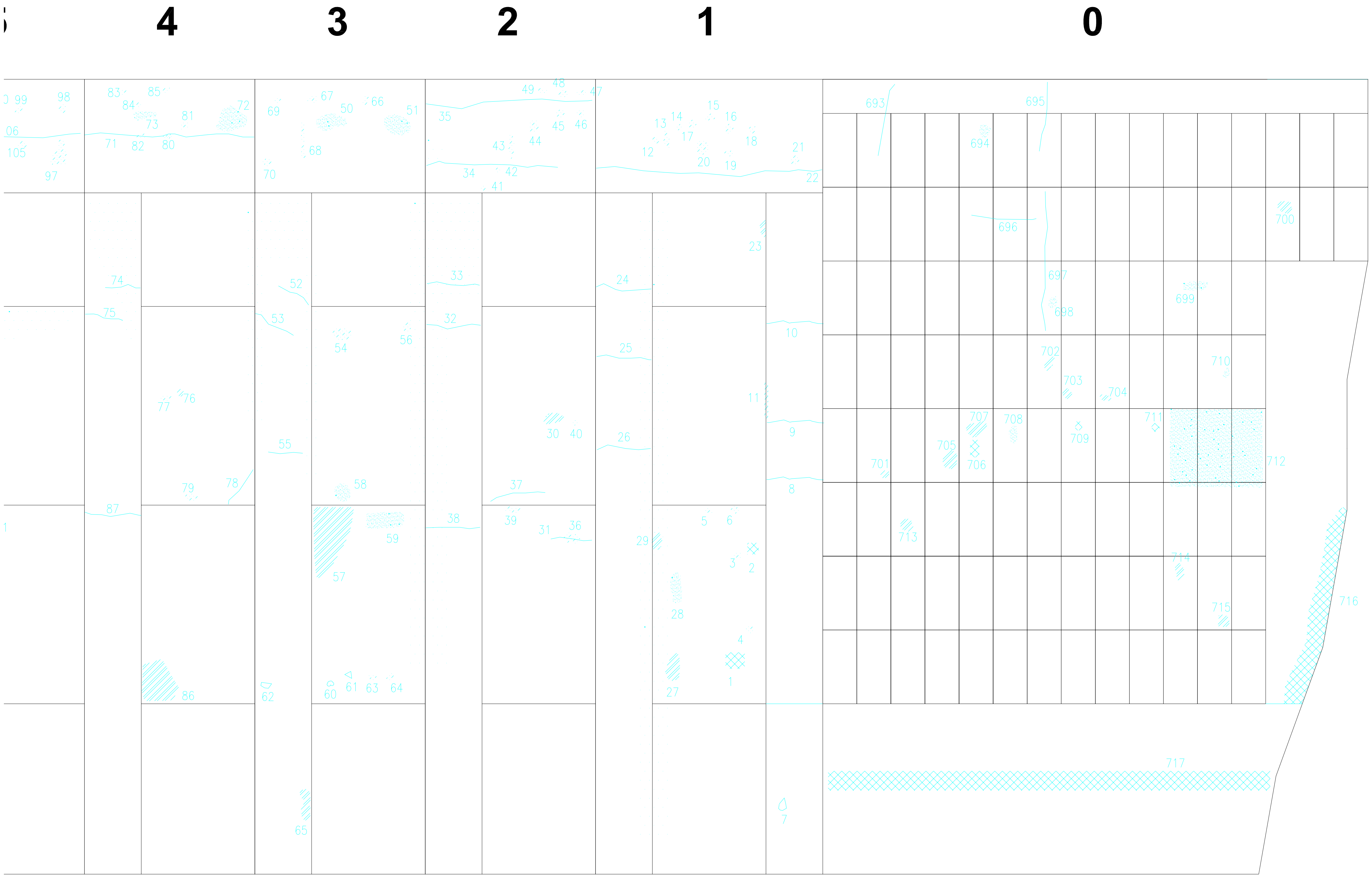
Drawn By: GN | Date: May 07
Checked By: GN | Date: Jun 07
Approved By: SB | Date: Jun 07

Drawing Number: SUR07603/01 | Revision

Dwg Scale: NTS | Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

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Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / East Face
Test Area 0 to 4

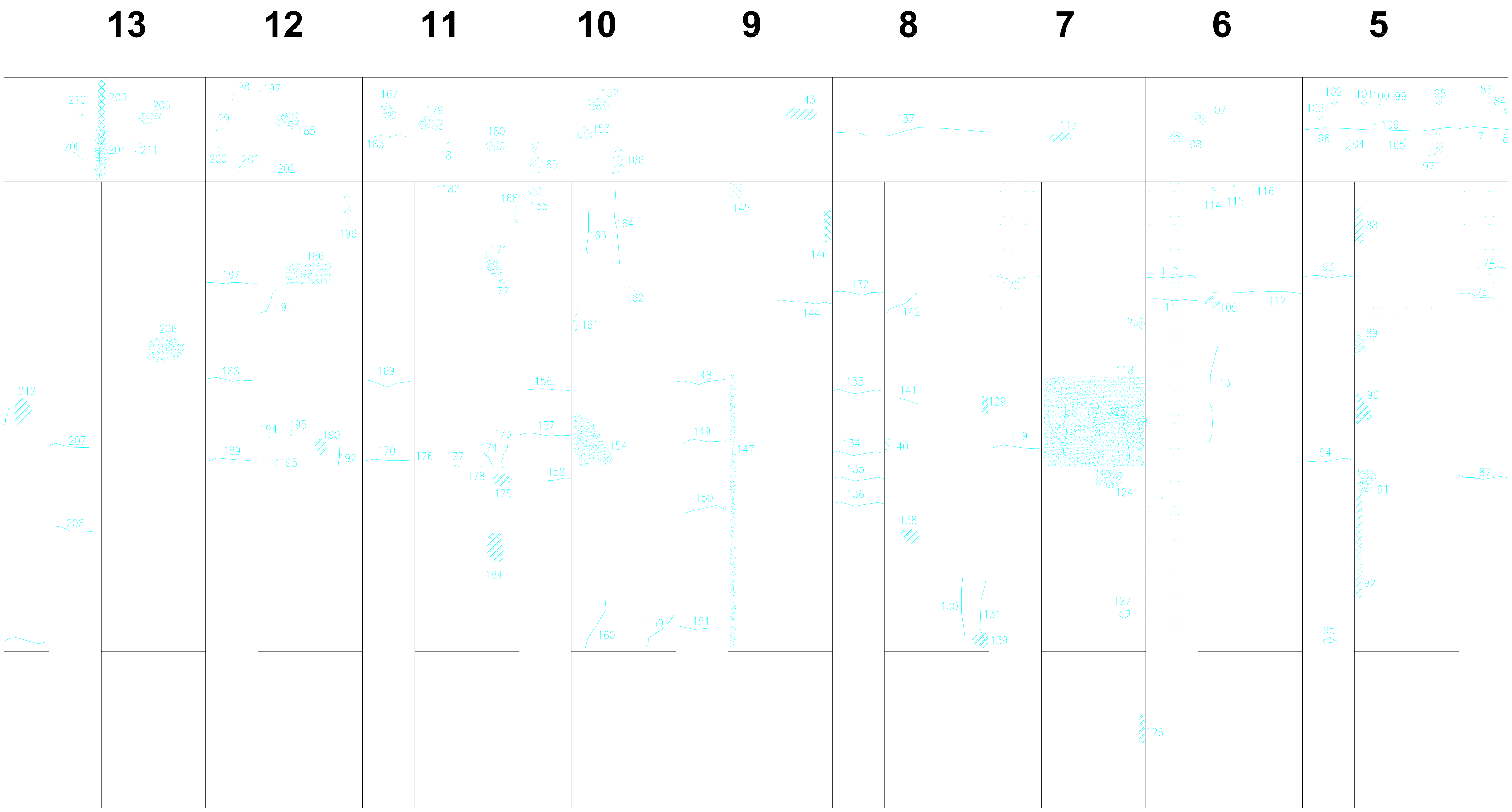
Drawn By: GN — Date: May 07
Checked By: GN — Date: Jun 07
Approved By: SB — Date: Jun 07

Drawing Number: SUR07603/02 — Revision

Dwg Scale: NTS — Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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Project Title:
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Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / East Face
Test Area 5 to 13

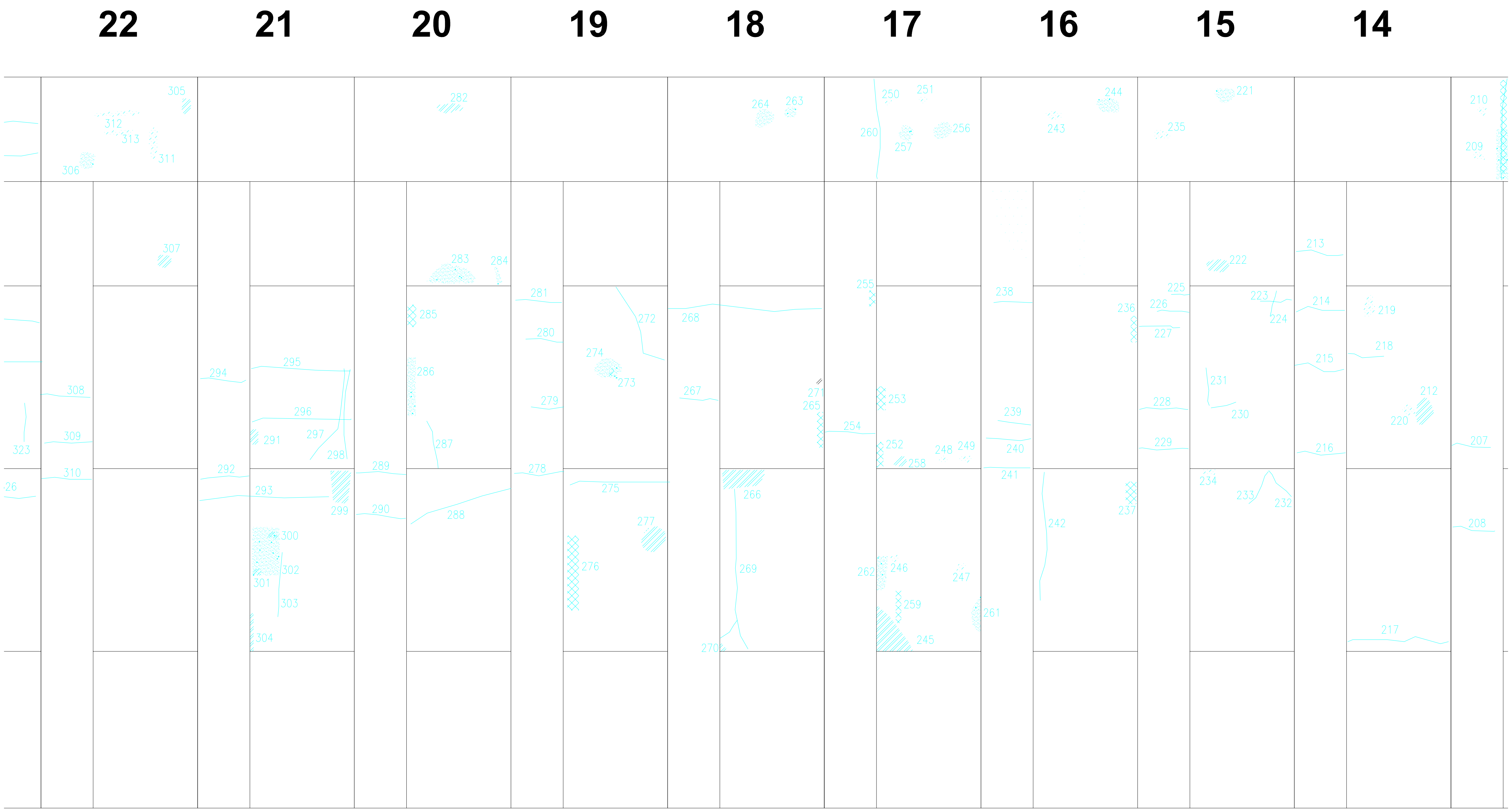
Drawn By:	GN	Date:	May 07
Checked By:	GN	Date:	Jun 07
Approved By:	SB	Date:	Jun 07

Drawing Number: SUR07603/03
Revision

Dwg Scale: NTS
Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

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Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / East Face
Test Area 14 to 22

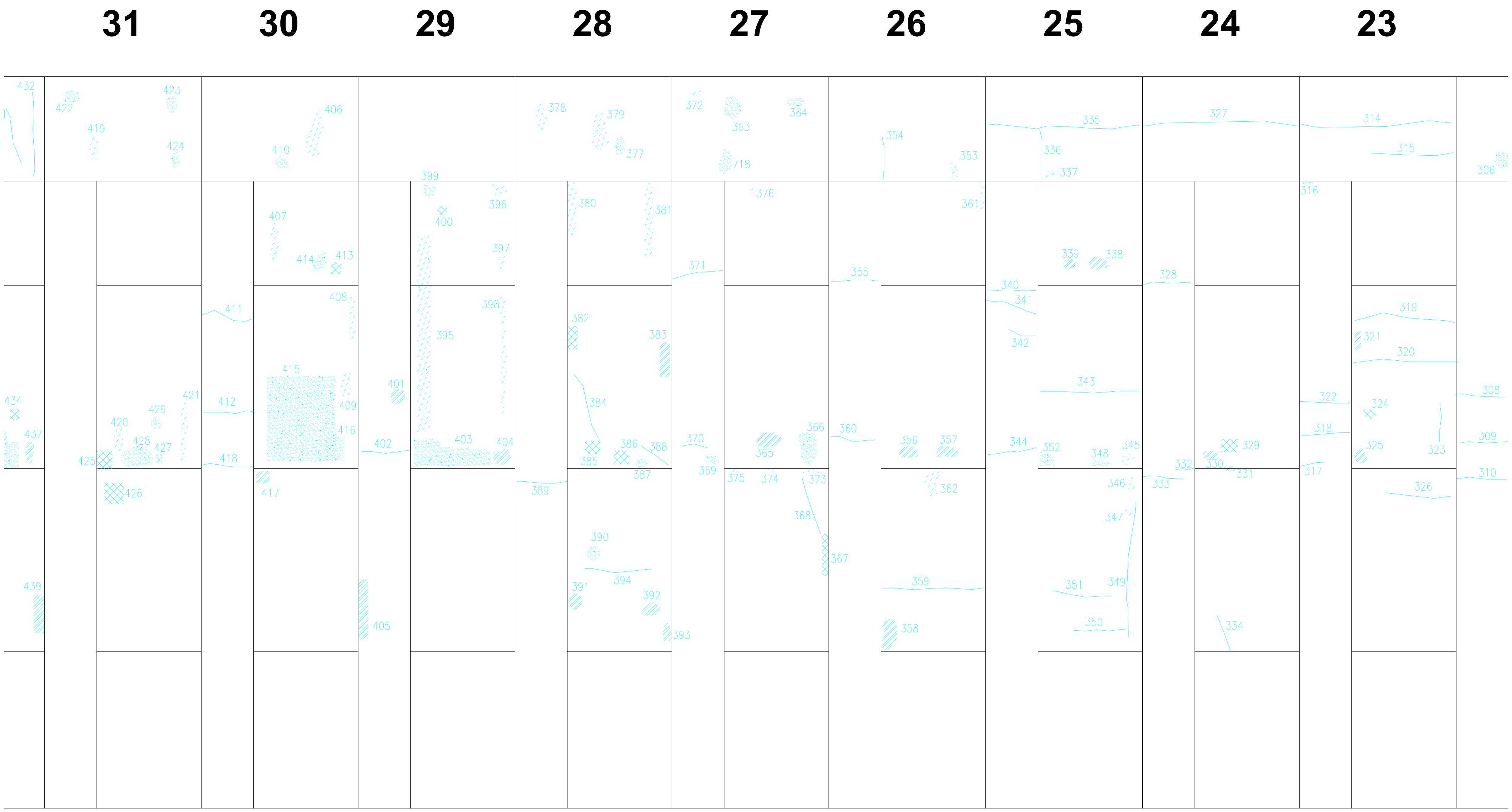
Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07

Drawing Number: SUR07603/04 Revision

Dwg Scale: NTS | Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- 131 Defect Reference Number
- S1 Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / East Face
Test Area 23 to 41

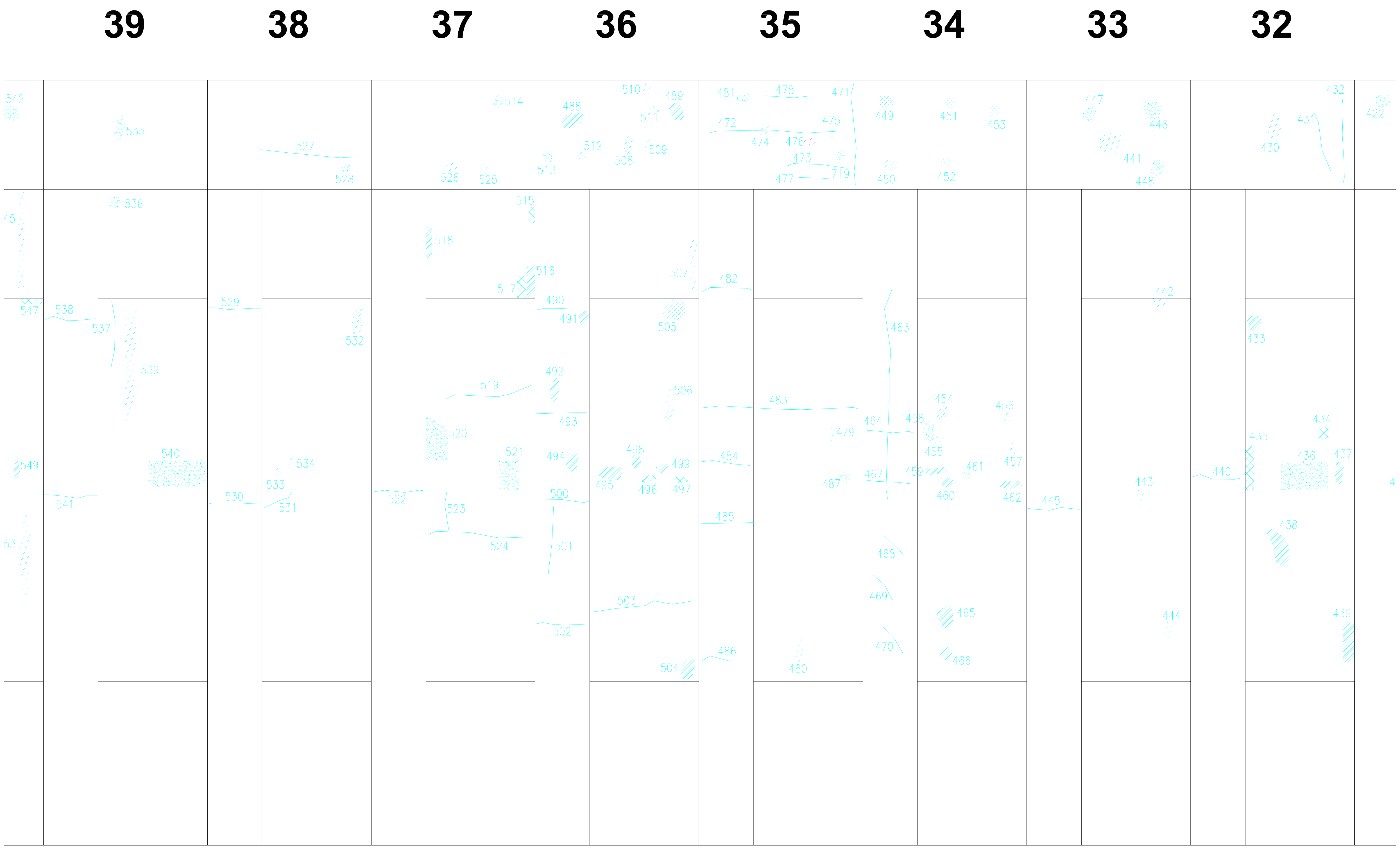
Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07

Drawing Number: SUR07603/06 Revision

Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- 131 Defect Reference Number
- S1 Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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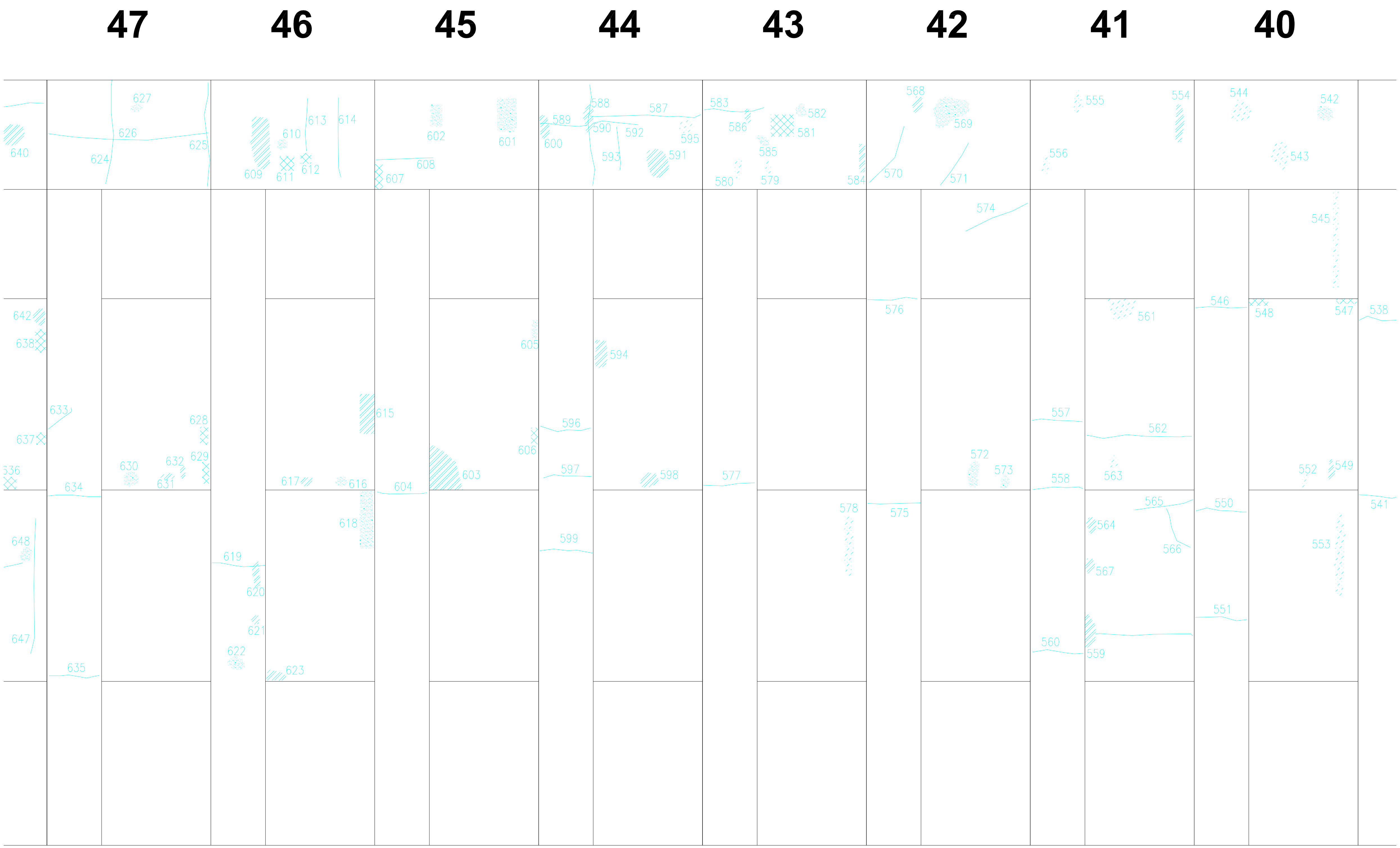
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / East Face
Test Area 32 to 39

Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07
Drawing Number: SUR07603/07 Revision
Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / East Face
Test Area 40 to 47

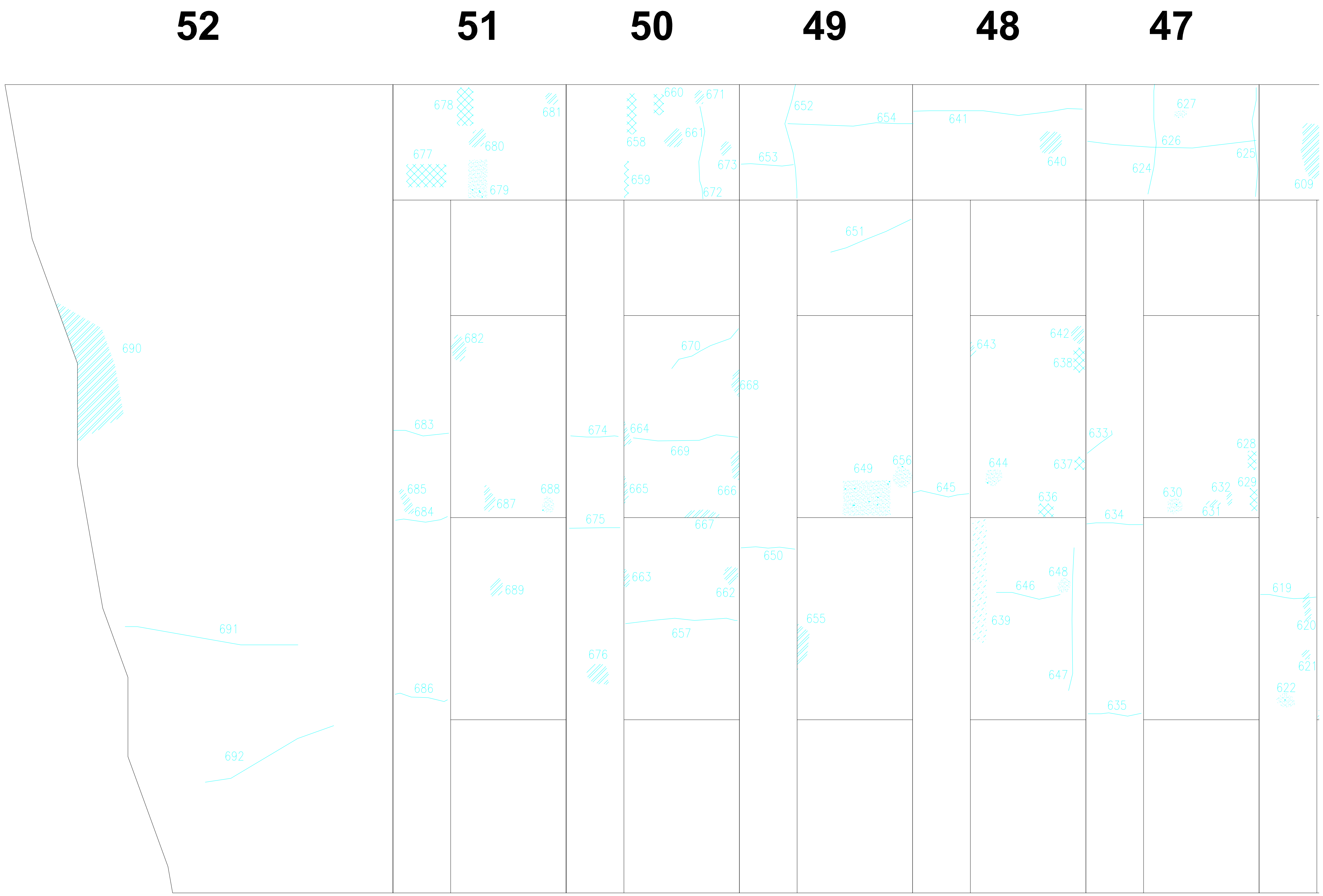
Drawn By:	GN	Date:	May 07
Checked By:	GN	Date:	Jun 07
Approved By:	SB	Date:	Jun 07

Drawing Number: SUR07603/08
Revision

Dwg Scale: NTS
Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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Town Hall
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Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / East Face
Test Area 47 to 52

Drawn By:	GN	Date:	May 07
Checked By:	GN	Date:	Jun 07
Approved By:	SB	Date:	Jun 07

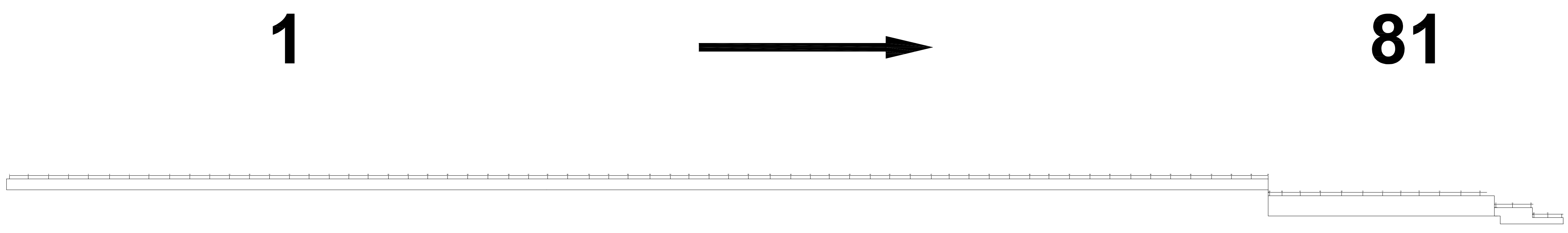
Drawing Number: SUR07603/09
Revision

Dwg Scale: NTS
Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

9.2 DRAWINGS - WEST FACE / PARAPET WALL

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- 131 Defect Reference Number
- S1 Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CATHITE HOUSE
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North Yorkshire, YO11 2HG

Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas Arrangement

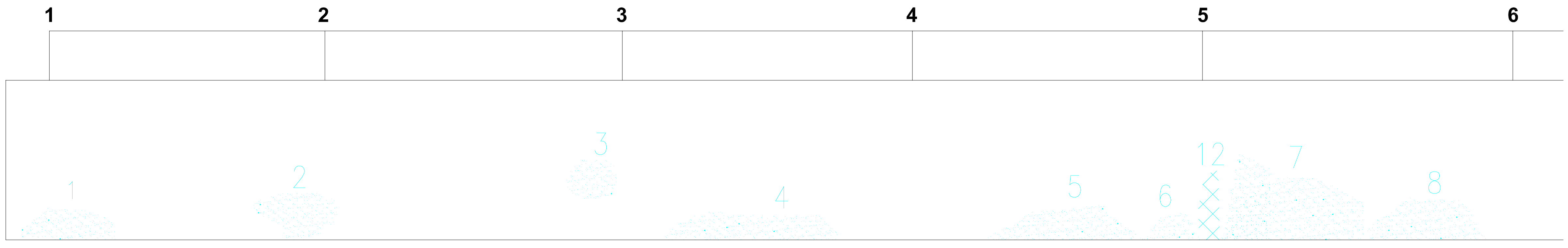
Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07

Drawing Number: SUR07603/10
Revision:

Dwg Scale: NTS
Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
Structural and building assessment
CATHITE HOUSE
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T: +44 (020) 8288 4848
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E: mail@concrete-repairs.co.uk
W: www.concrete-repairs.co.uk

Client: Scarborough Borough Council
Town Hall
St. Nicolas Street, Scarborough
North Yorkshire, YO11 2HG

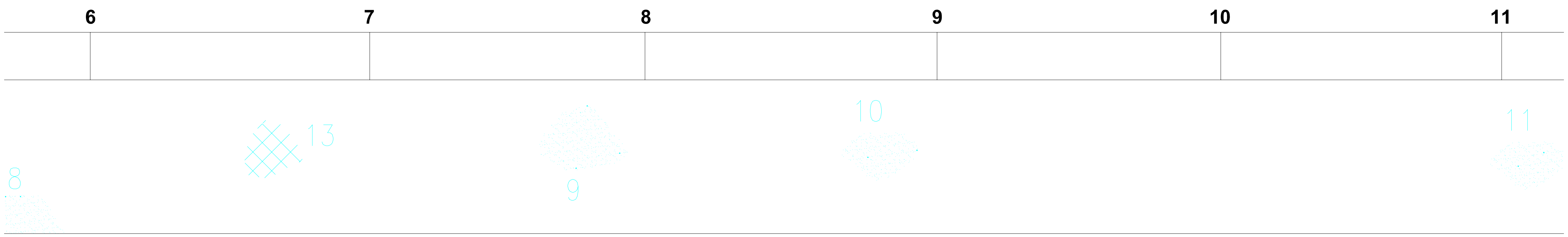
Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 1 to 5

Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07
Drawing Number: SUR07603/11 Revision
Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- S1 Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CATHITE HOUSE
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Client: Scarborough Borough Council
Town Hall
St. Nicolas Street, Scarborough
North Yorkshire, YO11 2HG

Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 6 to 11

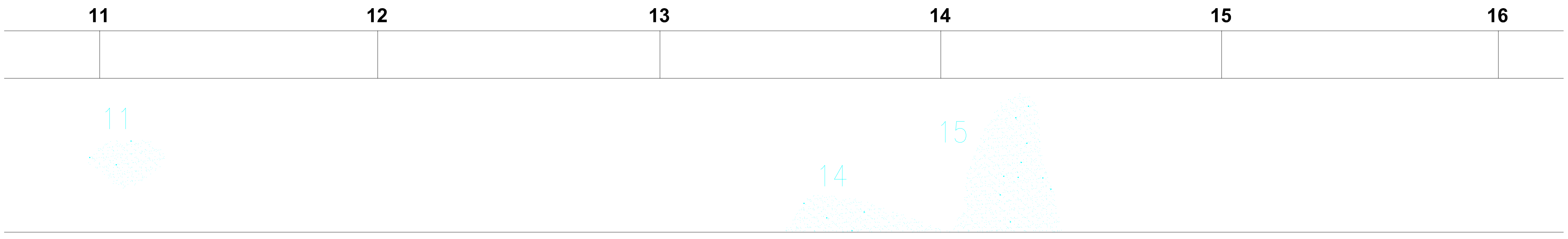
Drawn By:	GN	Date:	May 07
Checked By:	GN	Date:	Jun 07
Approved By:	SB	Date:	Jun 07

Drawing Number: SUR07603/28
Revision:

Dwg Scale: NTS
Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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Client: Scarborough Borough Council
Town Hall
St. Nicolas Street, Scarborough
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Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 11 to 15

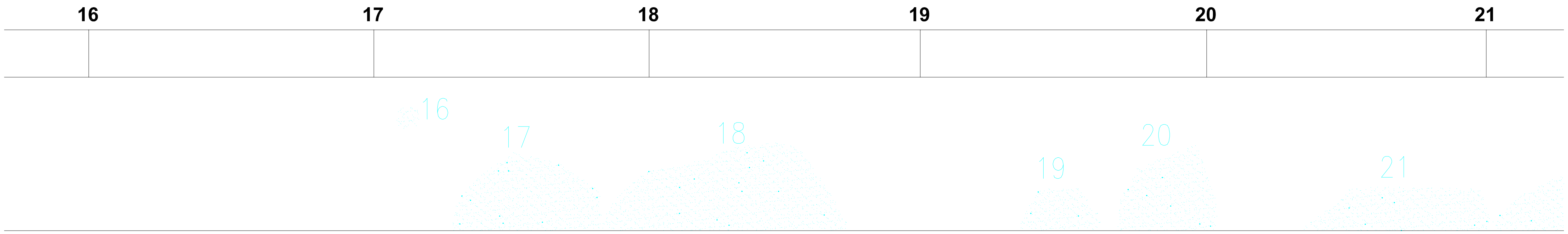
Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07

Drawing Number: SUR07603/12 Revision

Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- 131 Defect Reference Number
- S1 Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
Structural and building assessment
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St. Nicolas Street, Scarborough
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Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 16 to 20

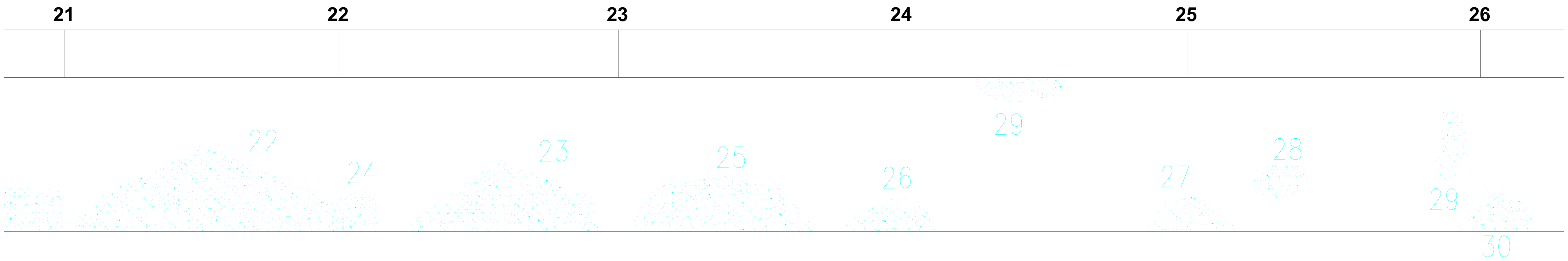
Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07

Drawing Number: SUR07603/13 Revision

Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
Structural and building assessment
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Town Hall
St. Nicolas Street, Scarborough
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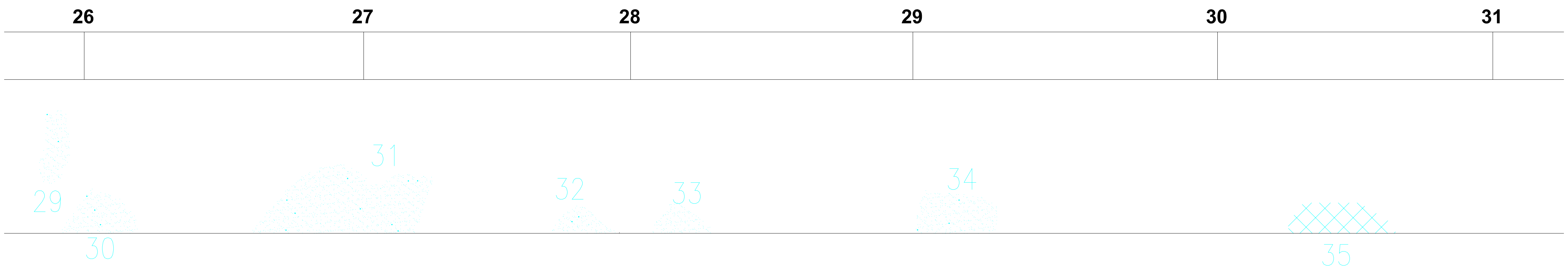
Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 21 to 25

Drawn By: GN		Date: May 07
Checked By: GN		Date: Jun 07
Approved By: SB		Date: Jun 07
Drawing Number: SUR07603/14		Revision
Dwg Scale: NTS	Dwg Status: Final	

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- 131 Defect Reference Number
- S1 Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
Structural and building assessment
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Client: Scarborough Borough Council
Town Hall
St. Nicolas Street, Scarborough
North Yorkshire, YO11 2HG

Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 26 to 30

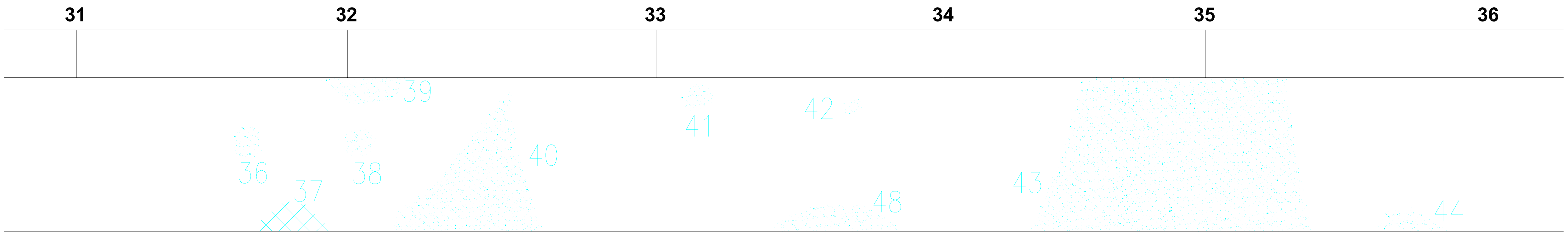
Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07

Drawing Number: SUR07603/15 Revision

Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
Structural and building assessment
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Client: Scarborough Borough Council
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Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 31 to 35

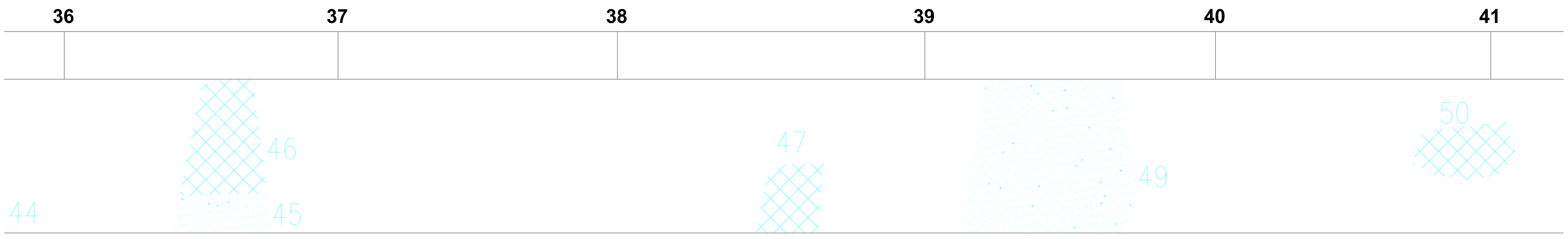
Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07

Drawing Number: SUR07603/16 Revision

Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
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CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
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- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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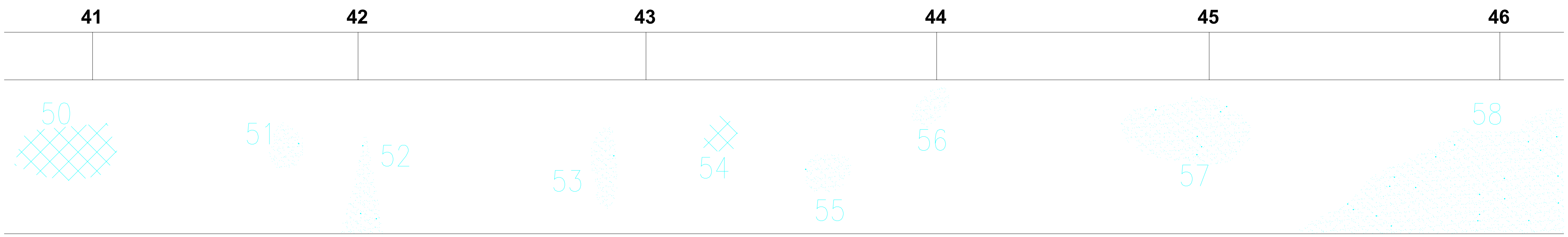
Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 36 to 40

Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07
Drawing Number: SUR07603/17 Revision
Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
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CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
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- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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Town Hall
St. Nicolas Street, Scarborough
North Yorkshire, YO11 2HG

Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 41 to 45

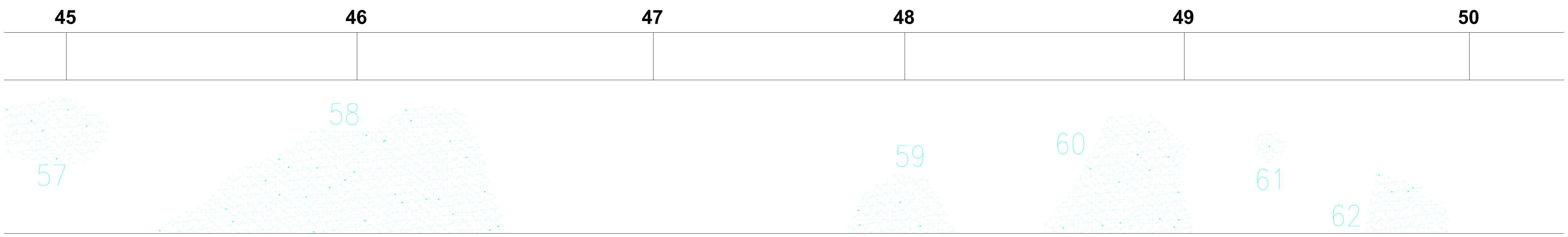
Drawn By:	GN	Date:	May 07
Checked By:	GN	Date:	Jun 07
Approved By:	SB	Date:	Jun 07

Drawing Number: SUR07603/18
Revision

Dwg Scale: NTS
Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
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CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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W: www.concrete-repairs.co.uk

Client: Scarborough Borough Council
Town Hall
St. Nicolas Street, Scarborough
North Yorkshire, YO11 2HG

Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 45 to 49

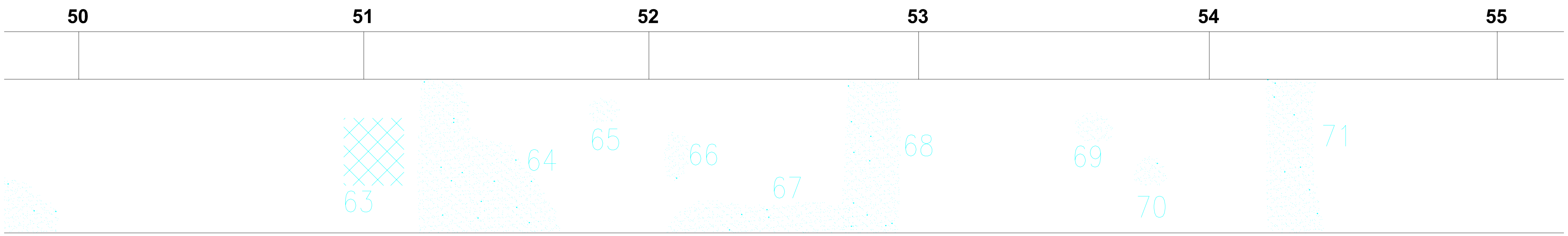
Drawn By: GN — Date: May 07
Checked By: GN — Date: Jun 07
Approved By: SB — Date: Jun 07

Drawing Number: SUR07603/19 — Revision

Dwg Scale: NTS — Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
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CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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W: www.concrete-repairs.co.uk

Client:
Scarborough Borough Council
Town Hall
St. Nicolas Street, Scarborough
North Yorkshire, YO11 2HG

Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 50 to 54

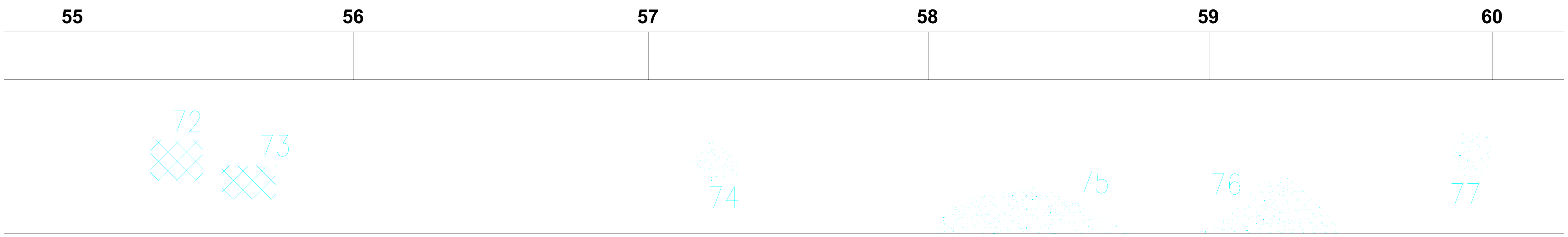
Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07

Drawing Number: SUR07603/20 Revision

Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
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CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CATHITE HOUSE
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W: www.concrete-repairs.co.uk

Client:
Scarborough Borough Council
Town Hall
St. Nicolas Street, Scarborough
North Yorkshire, YO11 2HG

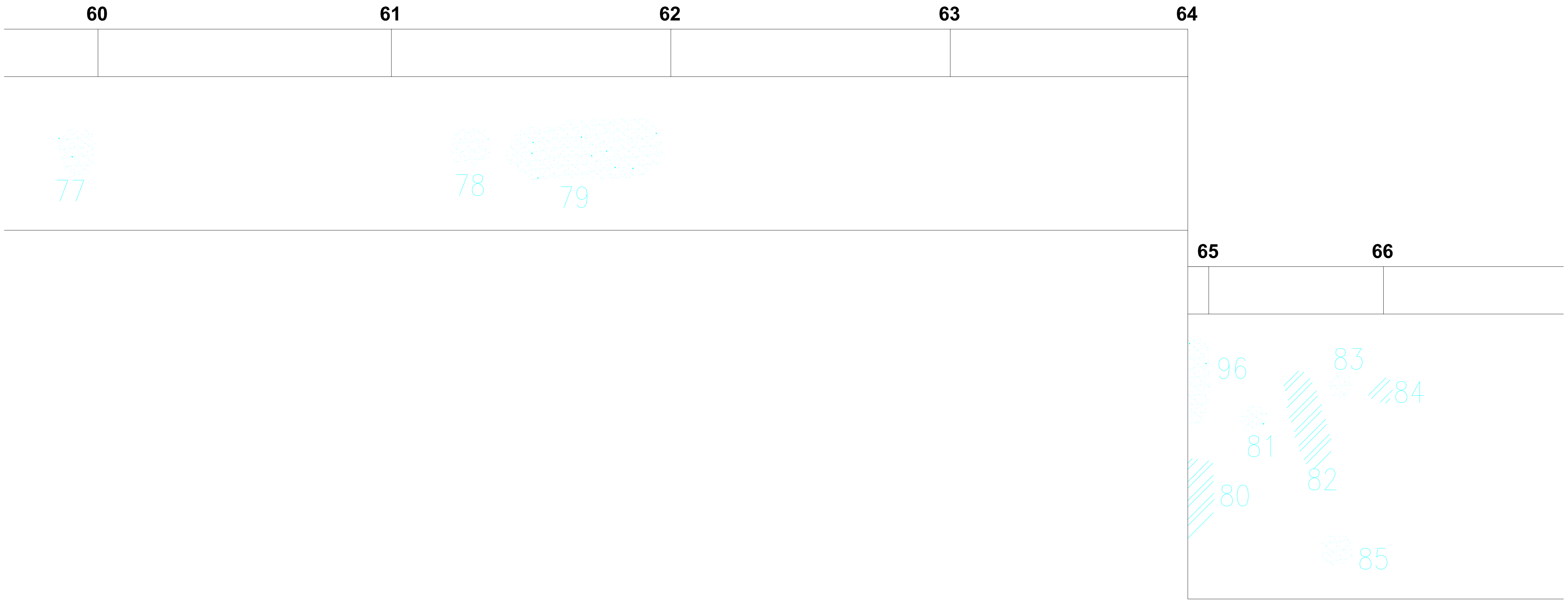
Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 55 to 59

Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07
Drawing Number: SUR07603/21 Revision
Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
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2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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W: www.concrete-repairs.co.uk

Client: Scarborough Borough Council
Town Hall
St. Nicolas Street, Scarborough
North Yorkshire, YO11 2HG

Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 60 to 65

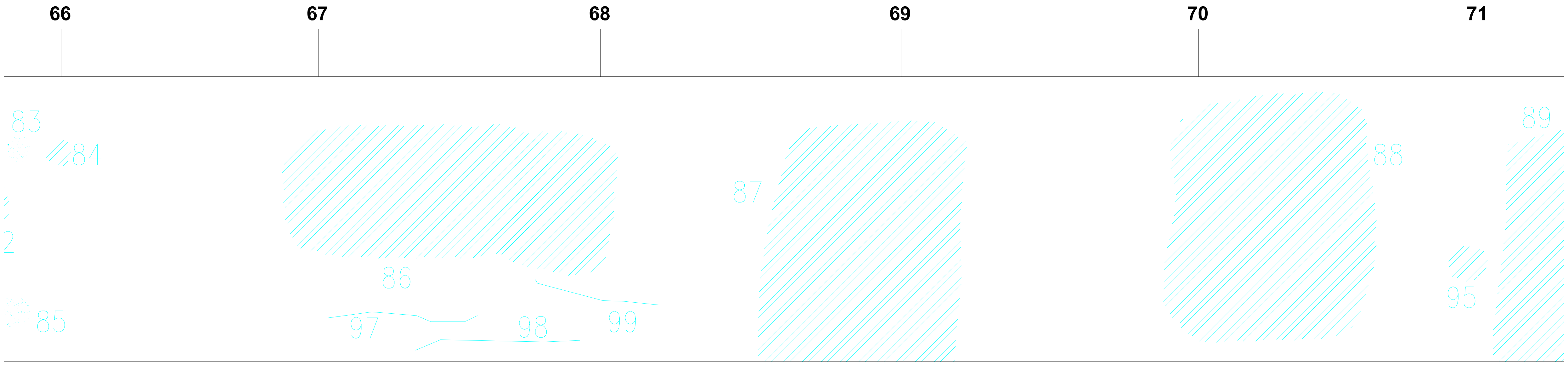
Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07

Drawing Number: SUR07603/22 Revision

Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
Structural and building assessment
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E: mail@concrete-repairs.co.uk
W: www.concrete-repairs.co.uk

Client: Scarborough Borough Council
Town Hall
St. Nicolas Street, Scarborough
North Yorkshire, YO11 2HG

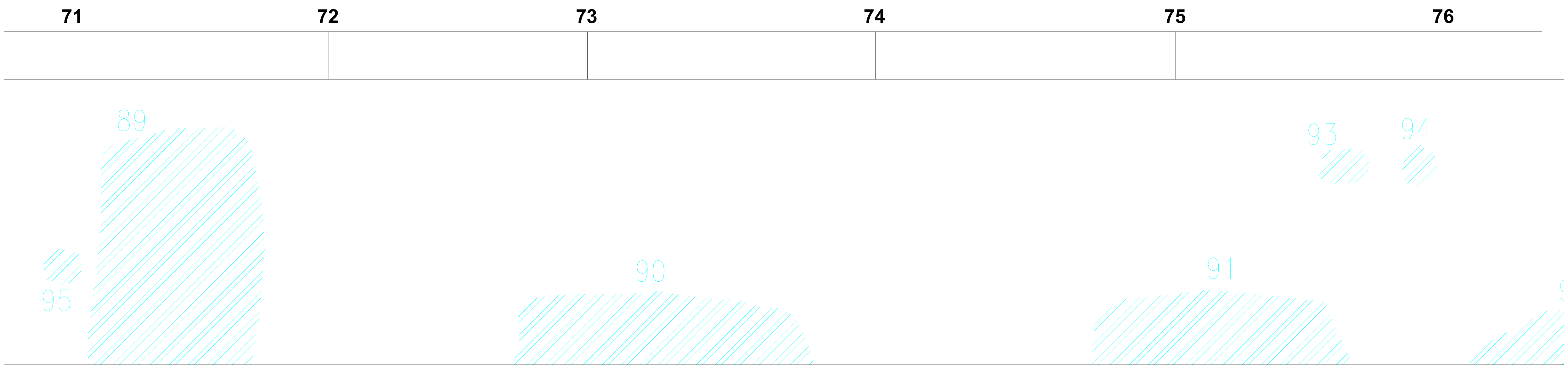
Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 66 to 70

Drawn By: GN		Date: May 07
Checked By: GN		Date: Jun 07
Approved By: SB		Date: Jun 07
Drawing Number: SUR07603/23		Revision
Dwg Scale: NTS	Dwg Status: Final	

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
- Visible Steel
- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- Defect Reference Number
- Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CRL SURVEYS
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W: www.concrete-repairs.co.uk

Client: Scarborough Borough Council
Town Hall
St. Nicolas Street, Scarborough
North Yorkshire, YO11 2HG

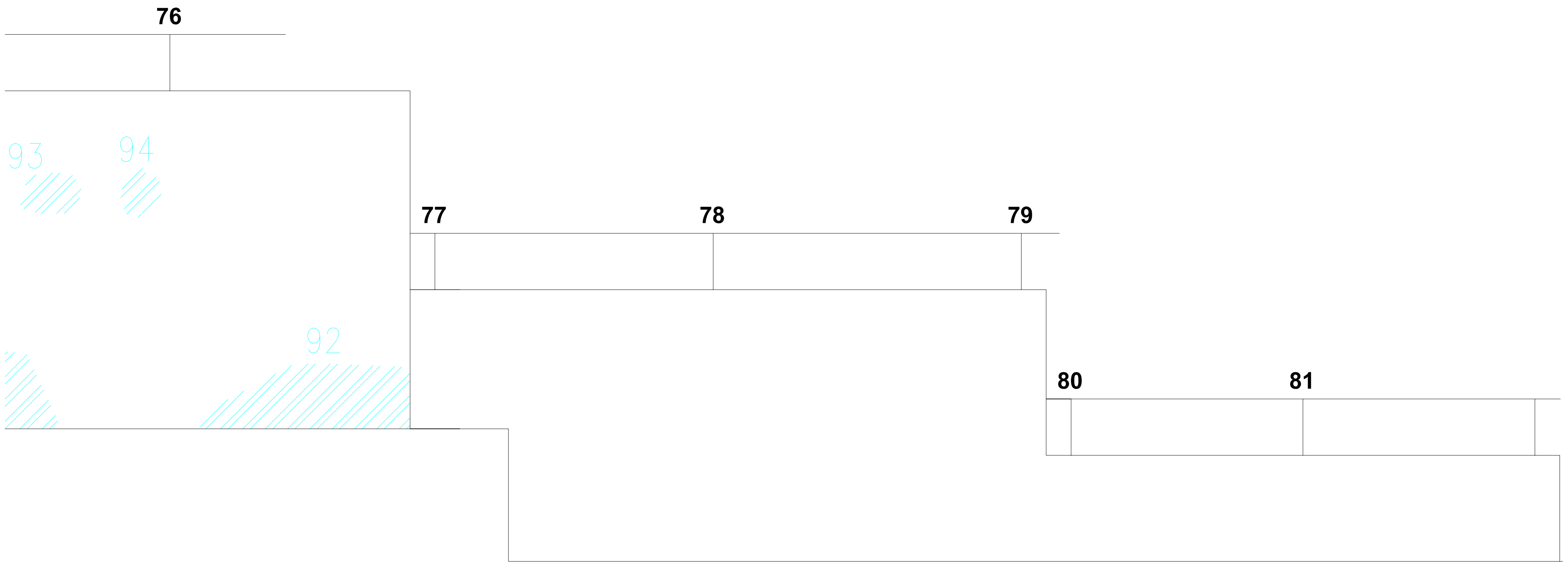
Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 71 to 75

Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07
Drawing Number: SUR07603/24 Revision
Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

DO NOT SCALE



Notes:
1. Sizes and Locations of defects are indicative only.
2. Do not scale this drawing.

CRL SURVEYS
VISUAL INSPECTION LEGEND

- Spalled Concrete
- Incipient Spall
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- Hollow / Delaminated
- Previous Repair
- Honeycombing
- Water Staining
- White Deposits
- Crack
- Multiple Cracking / Surface Crazing
- Joint
- Tie Wire
- Degraded Pyritous Aggregates
- 131 Defect Reference Number
- S1 Sample Reference
- Extent of Test Area

Revision	By	Date	CG/App	Description

CATHITE HOUSE
23A WILLOW LANE
MITCHAM
SURREY
CR4 4TU
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E: mail@concrete-repairs.co.uk
W: www.concrete-repairs.co.uk

Client: Scarborough Borough Council
Town Hall
St. Nicolas Street, Scarborough
North Yorkshire, YO11 2HG

Project Title:
Sea Wall
Robin Hood's Bay

Drawing Title:
Survey and Investigation
Sea Wall / West Face
Test Areas 76 to 81

Drawn By: GN Date: May 07
Checked By: GN Date: Jun 07
Approved By: SB Date: Jun 07

Drawing Number: SUR07603/25 Revision

Dwg Scale: NTS Dwg Status: Final

CAD Filename: SUR7603/Drawings/Greg

10. APPENDIX C: CRL DEFECTS SCHEDULES

10.1 DEFECTS SCHEDULE - EAST FACE / MAIN WALL

CRL SURVEYS
Structural and building assessment

Cathite House, 23a Willow Lane
Mitcham, Surrey, CR4 4TU
Tel: 0208 288 4848
Fax: 0208 288 4847
www.concrete-repairs.co.uk

Contract Details:

Contract Ref:	SUR07603
Contract Name:	Sea Wall
Element:	East Face
Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
1	150	100		p	Previous Repair
2	200	200		p	Previous Repair
3	50	50		s	Degraded Pyritous Aggregates
4	100	100		s	Degraded Pyritous Aggregates
5	300	300		s	Degraded Pyritous Aggregates
6	150	150		s	Degraded Pyritous Aggregates
7	100	100		p	Chipped Concrete
8	1000			c	Crack
9	1000			c	Crack
10	1000			c	Crack
11	500	150		s	White Deposit
12	50	50		s	Degraded Pyritous Aggregates
13	300	300		s	Degraded Pyritous Aggregates
14	50	50		s	Degraded Pyritous Aggregates
15	50	50		s	Degraded Pyritous Aggregates
16	50	50		s	Degraded Pyritous Aggregates
17	200	200		s	Degraded Pyritous Aggregates
18	50	50		s	Degraded Pyritous Aggregates
19	50	50		s	Degraded Pyritous Aggregates
20	50	50		s	Degraded Pyritous Aggregates
21	50	50		s	Degraded Pyritous Aggregates
22	3500			c	Crack
23	150	50	50	a	Spalled Concrete
24	1000			c	Crack
25	1000			c	Crack
26	1000			c	Crack
27	500	200		p	Spalled Concrete
28	300	300		p	Hollow / Delaminated
29	50	50		p	Spalled Concrete
30	150	150		p	Spalled Concrete
31	800			c	Crack
32	1000			c	Crack
33	1000			c	Crack
34	2500			c	Crack
35	3000			c	Crack
36	300	300		s	Degraded Pyritous Aggregates
37	500			c	Crack
38	1000			c	Crack
39	250	50		s	Degraded Pyritous Aggregates
40	100	100		s	Degraded Pyritous Aggregates

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Contract Details:	
Contract Ref:	SUR07603
Contract Name:	Sea Wall
Element:	East Face
Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
41	30	30		s	Degraded Pyritous Aggregates
42	50	50		s	Degraded Pyritous Aggregates
43	150	200		s	Degraded Pyritous Aggregates
44	500	500		s	Degraded Pyritous Aggregates
45	50	50		s	Degraded Pyritous Aggregates
46	50	50		s	Degraded Pyritous Aggregates
47	30	30		s	Degraded Pyritous Aggregates
48	30	30		s	Degraded Pyritous Aggregates
49	30	30		s	Degraded Pyritous Aggregates
50	300	300		p	Hollow / Delaminated
51	400	300		p	Hollow / Delaminated
52	500			c	Crack
53	400			c	Crack
54	50	50		s	Degraded Pyritous Aggregates
55	300			c	Crack
56	50	50		s	Degraded Pyritous Aggregates
57	700	300	50	a	Spalled Concrete
58	300	300		p	Hollow / Delaminated
59	500	400		p	Hollow / Delaminated
60	30	30		p	Chipped Concrete
61	50	50		p	Chipped Concrete
62	50	50		p	Chipped Concrete
63	30	30		s	Degraded Pyritous Aggregates
64	30	30		s	Degraded Pyritous Aggregates
65	50	150		p	Spalled Concrete
66	50	50		s	Degraded Pyritous Aggregates
67	50	50		s	Degraded Pyritous Aggregates
68	100	300		s	Degraded Pyritous Aggregates
69	50	50		s	Degraded Pyritous Aggregates
70	50	50		s	Degraded Pyritous Aggregates
71	3000			c	Crack
72	700	400		p	Hollow / Delaminated
73	400	300		p	Hollow / Delaminated
74	500			c	Crack
75	700			c	Crack
76	50	50		p	Spalled Concrete
77	50	50		s	Degraded Pyritous Aggregates
78	400			c	Crack
79	50	50		s	Degraded Pyritous Aggregates
80	150	50		s	Degraded Pyritous Aggregates

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		Contract Ref:	SUR07603
		Contract Name:	Sea Wall
		Element:	East Face
		Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
81	150	50		s	Degraded Pyritous Aggregates
82	200	100		s	Degraded Pyritous Aggregates
83	150	50		s	Degraded Pyritous Aggregates
84	150	50		s	Degraded Pyritous Aggregates
85	150	50		s	Degraded Pyritous Aggregates
86	300	300		p	Spalled Concrete
87	1000			c	Crack
88	50	400		p	Previous Repair
89	100	100		p	Spalled Concrete
90	150	150		p	Spalled Concrete
91	150	400		p	Hollow / Delaminated
92	2500	100	30	a	Previous Repair
93	1000			c	Crack
94	1000			c	Crack
95	100	50		p	Chipped Concrete
96	3000			c	Crack
97	150	150		s	Degraded Pyritous Aggregates
98	50	50		s	Degraded Pyritous Aggregates
99	50	50		s	Degraded Pyritous Aggregates
100	50	50		s	Degraded Pyritous Aggregates
101	50	50		s	Degraded Pyritous Aggregates
102	150	50		s	Degraded Pyritous Aggregates
103	150	50		s	Degraded Pyritous Aggregates
104	100	100		s	Degraded Pyritous Aggregates
105	100	100		s	Degraded Pyritous Aggregates
106	50	50		s	Degraded Pyritous Aggregates
107	200	200		p	Hollow / Delaminated
108	200	200		p	Hollow / Delaminated
109	200	100		p	Incipient Spall
110	1000			c	Crack
111	1000			c	Crack
112	1000			c	Crack
113	1000			c	Crack
114	200	100		s	Degraded Pyritous Aggregates
115	300	100		s	Degraded Pyritous Aggregates
116	400	100		s	Degraded Pyritous Aggregates
117	200	100		p	Previous Repair
118	2000	1500		p	Hollow / Delaminated
119	1000			c	Crack
120	1000			c	Crack

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Contract Details:	
Contract Ref:	SUR07603
Contract Name:	Sea Wall
Element:	East Face
Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
121	700			c	Crack
122	1000			c	Crack
123	1000			c	Crack
124	700	500		p	Hollow / Delaminated
125	300	300		p	Hollow / Delaminated
126	100	300	50	a	Spalled Concrete
127	50	50		p	Chipped Concrete
128	400	200		p	Previous Repair
129	100	100		p	Spalled Concrete
130	800			c	Crack
131	500			c	Crack
132	900			c	Crack
133	800			c	Crack
134	500			c	Crack
135	500			c	Crack
136	500			c	Crack
137	3000			c	Crack
138	200	200		p	Spalled Concrete
139	100	100		p	Spalled Concrete
140	150	50		p	Previous Repair
141	500			c	Crack
142	500			c	Crack
143	200	150		p	Spalled Concrete
144	1000			c	Crack
145	400	400		p	Previous Repair
146	400	50		p	Previous Repair
147	4000	200		p	Hollow / Delaminated
148	800			c	Crack
149	800			c	Crack
150	800			c	Crack
151	1000			c	Crack
152	300	300		p	Hollow / Delaminated
153	200	200		p	Hollow / Delaminated
154	800	800		p	Hollow / Delaminated
155	150	100		p	Previous Repair
156	1000			c	Crack
157	1000			c	Crack
158	500			c	Crack
159	300			c	Crack
160	1000			c	Crack

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		Contract Name:	Sea Wall
		Element:	East Face
		Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
161	500	100		s	Degraded Pyritous Aggregates
162	150	100		s	Degraded Pyritous Aggregates
163	600			c	Crack
164	1000			c	Crack
165	500	200		s	Degraded Pyritous Aggregates
166	500	200		s	Degraded Pyritous Aggregates
167	200	200		p	Hollow / Delaminated
168	200	50		p	Previous Repair
169	900			c	Crack
170	1000			c	Crack
171	400	400		p	Hollow / Delaminated
172	100	100		p	Spalled Concrete
173	500			c	Crack
174	300			c	Crack
175	400	300		p	Spalled Concrete
176	50	50		s	Degraded Pyritous Aggregates
177	50	50		s	Degraded Pyritous Aggregates
178	50	50		s	Degraded Pyritous Aggregates
179	100	100		p	Hollow / Delaminated
180	400	200		p	Hollow / Delaminated
181	150	50		s	Degraded Pyritous Aggregates
182	50	50		s	Degraded Pyritous Aggregates
183	400	200		s	Degraded Pyritous Aggregates
184	400	300		p	Spalled Concrete
185	400	300		p	Hollow / Delaminated
186	1000	500		p	Hollow / Delaminated
187	1000			c	Crack
188	1000			c	Crack
189	1000			c	Crack
190	200	200		p	Spalled Concrete
191	1000			c	Crack
192	400			c	Crack
193	100	100		s	Degraded Pyritous Aggregates
194	50	50		s	Degraded Pyritous Aggregates
195	150	150		s	Degraded Pyritous Aggregates
196	500	100		s	Degraded Pyritous Aggregates
197	50	50		s	Degraded Pyritous Aggregates
198	50	50		s	Degraded Pyritous Aggregates
199	50	50		s	Degraded Pyritous Aggregates
200	50	50		s	Degraded Pyritous Aggregates
201	50	50		s	Degraded Pyritous Aggregates
202	50	50		s	Degraded Pyritous Aggregates
203	1000	100		p	Previous Repair
204	1000	100		p	Hollow / Delaminated + Previous Repair

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Contract Details:

Contract Ref:	SUR07603
Contract Name:	Sea Wall
Element:	East Face
Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
205	200	200		p	Hollow / Delaminated
206	500	500		p	Hollow / Delaminated

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		Contract Ref:	SUR07603
		Contract Name:	Sea Wall
		Element:	East Face
		Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
207	800			c	Crack
208	700			c	Crack
209	100	100		s	Degraded Pyritous Aggregates
210	100	100		s	Degraded Pyritous Aggregates
211	100	100		s	Degraded Pyritous Aggregates
212	300	200		p	Spalled Concrete
213	700			c	Crack
214	1000			c	Crack
215	700			c	Crack
216	1000			c	Crack
217	2000			c	Crack
218	400			c	Crack
219	400	150		s	Degraded Pyritous Aggregates
220	300	150		s	Degraded Pyritous Aggregates
221	200	200		p	Hollow / Delaminated
222	300	300		p	Spalled Concrete
223	400			c	Crack
224	500			c	Crack
225	300			c	Crack
226	500			c	Crack
227	700			c	Crack
228	1000			c	Crack
229	1000			c	Crack
230	500			c	Crack
231	400			c	Crack
232	500			c	Crack
233	500			c	Crack
234	100	50		s	Degraded Pyritous Aggregates
235	100	50		s	Degraded Pyritous Aggregates
236	300	150		p	Previous Repair
237	400	200		p	Previous Repair
238	900			c	Crack
239	800			c	Crack
240	1000			c	Crack
241	1000			c	Crack
242	2500			c	Crack
243	150	50		s	Degraded Pyritous Aggregates
244	400	300		p	Hollow / Delaminated
245	500	300	50	a	Spalled Concrete
246	100	100		s	Degraded Pyritous Aggregates
247	100	100		s	Degraded Pyritous Aggregates
248	100	100		s	Degraded Pyritous Aggregates

CRL SURVEYS Structural and building assessment	Cathite House, 23a Willow Lane Mitcham, Surrey, CR4 4TU Tel: 0208 288 4848 Fax: 0208 288 4847 www.concrete-repairs.co.uk	**Contract Details:** Contract Ref: SUR07603 Contract Name: Sea Wall Element: East Face Date: Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
249	100	100		s	Degraded Pyritous Aggregates
250	50	50		s	Degraded Pyritous Aggregates
251	50	50		s	Degraded Pyritous Aggregates
252	500	100		p	Previous Repair
253	400	100		p	Previous Repair
254	1000			c	Crack
255	100	50		p	Previous Repair
256	300	300		p	Hollow / Delaminated
257	200	200		p	Hollow / Delaminated
258	150	150		p	Spalled Concrete
259	500	250		p	Previous Repair
260	1000			c	Crack
261	400	150		p	Hollow / Delaminated
262	500	200		p	Hollow / Delaminated
263	150	150		p	Hollow / Delaminated
264	200	200		p	Hollow / Delaminated
265	400	150		p	Previous Repair
266	400	150		p	Spalled Concrete
267	500			c	Crack
268	3000			c	Crack
269	3500			c	Crack
270	100	50		p	Spalled Concrete
271	150	100		p	Spalled Concrete
272	1500			c	Crack
273	200	150		p	Previous Repair
274	500	400		p	Hollow / Delaminated
275	2000			c	Crack
276	2000	150		p	Previous Repair
277	600	500		p	Spalled Concrete
278	1000			c	Crack
279	800			c	Crack
280	800			c	Crack
281	1000			c	Crack
282	300	200		p	Spalled Concrete
283	1000	500		p	Hollow / Delaminated
284	150	100		p	Spalled Concrete
285	300	200		p	Previous Repair
286	1200	200		p	Hollow / Delaminated
287	1000			c	Crack
288	2000			c	Crack
289	1000			c	Crack
290	1000			c	Crack

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Contract Details:	
Contract Ref:	SUR07603
Contract Name:	Sea Wall
Element:	East Face
Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
291	300	200		p	Spalled Concrete
292	1000			c	Crack
293	3000			c	Crack
294	1000			c	Crack
295	2000			c	Crack
296	2000			c	Crack
297	1000			c	Crack
298	1000			c	Crack
299	500	300		p	Spalled Concrete
300	100	100		p	Spalled Concrete
301	100	100		p	Spalled Concrete
302	500	300		p	Hollow / Delaminated
303	2000			c	Crack
304	500	50	20	a	Spalled Concrete
305	150	100		p	Spalled Concrete
306	150	150		p	Hollow / Delaminated
307	50	50		p	Spalled Concrete
308	1000			c	Crack
309	900			c	Crack
310	1000			c	Crack
311	500	100		s	Degraded Pyritous Aggregates
312	400	50		s	Degraded Pyritous Aggregates
313	400	50		s	Degraded Pyritous Aggregates
314	3000			c	Crack
315	2000			c	Crack
316	500	50		p	Hollow / Delaminated
317	200			c	Crack
318	900			c	Crack
319	2000			c	Crack
320	2000			c	Crack
321	200	150		p	Spalled Concrete
322	1000			c	Crack
323	500			c	Crack
324	150	150		p	Previous Repair
325	500	300		p	Spalled Concrete
326	1200			c	Crack
327	3000			c	Crack
328	1000			c	Crack
329	200	200		p	Previous Repair
330	150	100		p	Spalled Concrete
331	100	50	30	a	Spalled Concrete
332	300			c	Crack

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Element:	East Face
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Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
333	900			c	Crack
334	800			c	Crack
335	3000			c	Crack
336	1000			c	Crack
337	200	50		s	Degraded Pyritous Aggregates
338	400	300		p	Spalled Concrete
339	200	150		p	Spalled Concrete
340	1000			c	Crack
341	1100			c	Crack
342	700			c	Crack
343	2000			c	Crack
344	1000			c	Crack
345	100	100		s	Degraded Pyritous Aggregates
346	400	200		s	Degraded Pyritous Aggregates
347	50	50		s	Degraded Pyritous Aggregates
348	500	200		p	Hollow / Delaminated
349	1000			c	Crack
350	1000			c	Crack
351	1000			c	Crack
352	400	400		p	Hollow / Delaminated
353	50	50		s	Degraded Pyritous Aggregates
354	1000			c	Crack
355	1000			c	Crack
356	300	150		p	Spalled Concrete
357	300	200		p	Spalled Concrete
358	400	200	30	a	Spalled Concrete
359	300			c	Crack
360	500			c	Crack
361	500	100		s	Degraded Pyritous Aggregates
362	500	100		s	Degraded Pyritous Aggregates
363	600	600		p	Hollow / Delaminated
364	300	150		p	Hollow / Delaminated
365	400	400		p	Spalled Concrete
366	600	400		p	Hollow / Delaminated
367	500	200		p	Previous Repair
368	200			c	Crack
369	100	100		p	Hollow / Delaminated
370	200			c	Crack
371	1000			c	Crack
372	100	100		s	Degraded Pyritous Aggregates
373	400	100		s	Degraded Pyritous Aggregates
374	50	100		s	Degraded Pyritous Aggregates

CRL SURVEYS Structural and building assessment	Cathite House, 23a Willow Lane Mitcham, Surrey, CR4 4TU Tel: 0208 288 4848 Fax: 0208 288 4847 www.concrete-repairs.co.uk	**Contract Details:**	
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		Contract Name:	Sea Wall
		Element:	East Face
		Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
375	100	50		s	Degraded Pyritous Aggregates
376	300	50		s	Degraded Pyritous Aggregates
377	300	200		p	Hollow / Delaminated
378	500	200		s	Degraded Pyritous Aggregates
379	500	200		s	Degraded Pyritous Aggregates
380	1000	200		s	Degraded Pyritous Aggregates
381	1800	200		s	Degraded Pyritous Aggregates
382	500	300		p	Previous Repair
383	400	300		p	Spalled Concrete
384	1800			c	Crack
385	400	400		p	Previous Repair
386	400	300		p	Previous Repair
387	300	150		p	Hollow / Delaminated
388	500			c	Crack
389	1000			c	Crack
390	200	200		p	Hollow / Delaminated
391	300	200		p	Spalled Concrete
392	300	200		p	Spalled Concrete
393	300	200		p	Spalled Concrete
394	1000			c	Crack
395	3000	200		s	Degraded Pyritous Aggregates
396	300	200		s	Degraded Pyritous Aggregates
397	400	100		s	Degraded Pyritous Aggregates
398	200	100		s	Degraded Pyritous Aggregates
399	200	200		p	Hollow / Delaminated
400	200	200		p	Previous Repair
401	200	200		p	Splled Concrete
402	1000			c	Crack
403	1700	400		p	Previous Repair + Hollow / Delminated
404	300	300		p	Spalled Concrete
405	300	150		p	Spalled Concrete
406	500	100		s	Degraded Pyritous Aggregates
407	1000	100		s	Degraded Pyritous Aggregates
408	1500	100		s	Degraded Pyritous Aggregates
409	500	200		s	Degraded Pyritous Aggregates
410	200	200		p	Hollow / Delaminated
411	1000			c	Crack
412	1000			c	Crack
413	150	150		p	Previous Repair
414	300	200		p	Hollow / Delaminated
415	1800	2500		p	Hollow / Delaminated
416	300	200		p	Hollow / Delaminated
417	300	300		p	Splled Concrete
418	1000			c	Crack

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Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
419	200	100		s	Degraded Pyritous Aggregates
420	500	100		s	Degraded Pyritous Aggregates
421	1200	200		s	Degraded Pyritous Aggregates
422	150	150		p	Hollow / Delaminated
423	150	150		p	Hollow / Delaminated
424	300	150		p	Hollow / Delaminated
425	400	300		p	Previous Repair
426	300	150		p	Previous Repair
427	100	100		p	Previous Repair
428	500	400		p	Hollow / Delaminated
429	300	200		p	Hollow / Delaminated
430	200	100		s	Degraded Pyritous Aggregates
431	1000			c	Crack
432	800			c	Crack
433	100	50		p	Spalled Concrete

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Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
434	100	100		p	Previous Repair
435	1300	1500		p	Previous Repair
436	1200	600		p	Hollow / Delaminated
437	500	300		p	Spalled Concrete
438	400	400		p	Spalled Concrete
439	500	100		p	Spalled Concrete
440	1000			c	Crack
441	300	100		s	Degraded Pyritous Aggregates
442	200	100		s	Degraded Pyritous Aggregates
443	300	50		s	Degraded Pyritous Aggregates
444	400	100		s	Degraded Pyritous Aggregates
445	1000			c	Crack
446	200	200		p	Hollow / Delaminated
447	200	200		p	Hollow / Delaminated
448	200	200		p	Hollow / Delaminated
449	100	100		s	Degraded Pyritous Aggregates
450	100	50		s	Degraded Pyritous Aggregates
451	50	50		s	Degraded Pyritous Aggregates
452	50	50		s	Degraded Pyritous Aggregates
453	100	50		s	Degraded Pyritous Aggregates
454	100	100		s	Degraded Pyritous Aggregates
455	400	100		s	Degraded Pyritous Aggregates
456	400	100		s	Degraded Pyritous Aggregates
457	400	100		s	Degraded Pyritous Aggregates
458	150	150		p	Hollow / Delaminated
459	300	150		p	Spalled Concrete
460	300	300		p	Spalled Concrete
461	300	150		p	Hollow / Delaminated
462	500	200		p	Spalled Concrete
463	3600			c	Crack
464	1000			c	Crack
465	400	200		p	Spalled Concrete
466	150	150		p	Spalled Concrete
467	1000			c	Crack
468	400			c	Crack
469	300			c	Crack
470	100			c	Crack
471	2000			c	Crack
472	2000			c	Crack
473	500			c	Crack
474	150	50		s	Degraded Pyritous Aggregates
475	150	50		s	Degraded Pyritous Aggregates

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Contract Details:	
Contract Ref:	SUR07603
Contract Name:	Sea Wall
Element:	East Face
Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
476	150	50		s	Degraded Pyritous Aggregates
477	500			c	Crack
478	500			c	Crack
479	1000	50		s	Degraded Pyritous Aggregates
480	150	100		s	Degraded Pyritous Aggregates
481	300	300		p	Hollow / Delaminated
482	1000			c	Crack
483	3000			c	Crack
484	1000			c	Crack
485	1000			c	Crack
486	1000			c	Crack
487	200	150		p	Hollow / Delaminated
488	300	150		p	Spalled Concrete
489	300	300		p	Spalled Concrete
490	1000			c	Crack
491	300	50		p	Spalled Concrete
492	500	200		p	Spalled Concrete
493	800			c	Crack
494	300	100		p	Spalled Concrete
495	400	200		p	Spalled Concrete
496	300	150		p	Previous Repair
497	300	150		p	Previous Repair
498	200	150		p	Spalled Concrete
499	200	150		p	Spalled Concrete
500	1000			c	Crack
501	1000			c	Crack
502	1000			c	Crack
503	1800			c	Crack
504	300	150		p	Spalled Concrete
505	300	200		s	Degraded Pyritous Aggregates
506	1700	150		s	Degraded Pyritous Aggregates
507	1000	50		s	Degraded Pyritous Aggregates
508	300	150		s	Degraded Pyritous Aggregates
509	300	50		s	Degraded Pyritous Aggregates
510	50	50		s	Degraded Pyritous Aggregates
511	50	50		s	Degraded Pyritous Aggregates
512	150	150		s	Degraded Pyritous Aggregates
513	400	150		p	Hollow / Delaminated
514	100	100		p	Hollow / Delaminated
515	200	100		p	Previous Repair
516	800	100		p	Spalled Concrete
517	500	100		p	Previous Repair

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Contract Details:

Contract Ref:	SUR07603
Contract Name:	Sea Wall
Element:	East Face
Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
518	500	150		p	Previous Repair
519	1800			c	Crack
520	500	400		p	Hollow / Delaminated
521	800	400		p	Hollow / Delaminated
522	1000			c	Crack
523	1000			c	Crack
524	2000			c	Crack
525	50	50		s	Degraded Pyritous Aggregates
526	50	50		s	Degraded Pyritous Aggregates
527	1000			c	Crack
528	100	100		p	Hollow / Delaminated
529	1000			c	Crack
530	800			c	Crack
531	400			c	Crack
532	1000	100		s	Degraded Pyritous Aggregates
533	500	100		s	Degraded Pyritous Aggregates
534	500	100		s	Degraded Pyritous Aggregates
535	500	200		p	Hollow / Delaminated
536	150	150		p	Hollow / Delaminated
537	800			c	Crack
538	1000			c	Crack
539	2000	150		s	Degraded Pyritous Aggregates
540	800	1600		p	Hollow / Delaminated
541	1000			c	Crack
542	100	100		p	Hollow / Delaminated
543	400	200		s	Degraded Pyritous Aggregates
544	300	300		s	Degraded Pyritous Aggregates
545	2000	100		s	Degraded Pyritous Aggregates
546	1000			c	Crack
547	300	100		p	Previous Repair
548	200	100		p	Previous Repair
549	150	100		p	Spalled Concrete
550	1000			c	Crack
551	1000			c	Crack
552	200	100		s	Degraded Pyritous Aggregates
553	2000	150		s	Degraded Pyritous Aggregates
554	500	100		p	Spalled Concrete
555	300	100		s	Degraded Pyritous Aggregates
556	150	100		s	Degraded Pyritous Aggregates
557	900			c	Crack
558	1000			c	Crack
559	300	150		p	Spalled Concrete

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		Contract Name:	Sea Wall
		Element:	East Face
		Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
560	700			c	Crack
561	300	200		s	Degraded Pyritous Aggregates
562	1900			c	Crack
563	150	150		p	Hollow / Delaminated
564	150	150		p	Spalled Concrete
565	1000			c	Crack
566	1000			c	Crack
567	150	100		p	Spalled Concrete
568	100	50		p	Spalled Concrete
569	800	500		p	Hollow / Delaminated
570	1200			c	Crack
571	1300			c	Crack
572	500	300		p	Hollow / Delaminated
573	150	150		p	Hollow / Delaminated
574	1300			c	Crack
575	1000			c	Crack
576	1000			c	Crack
577	1000			c	Crack
578	1300	150		s	Degraded Pyritous Aggregates
579	500	100		s	Degraded Pyritous Aggregates
580	400	100		s	Degraded Pyritous Aggregates
581	500	500		p	Previous Repair
582	100	100		p	Hollow / Delaminated
583	1000			c	Crack
584	400	150		p	Spalled Concrete
585	200	200		p	Hollow / Delaminated
586	200	150		p	Spalled Concrete
587	2000			c	Crack
588	2000			c	Crack
589	1000			c	Crack
590	500	100		p	Spalled Concrete
591	600	500		p	Hollow / Delaminated
592	800			c	Crack
593	600			c	Crack
594	200	100		p	Spalled Concrete
595	300	150		s	Degraded Pyritous Aggregates
596	1000			c	Crack
597	1000			c	Crack
598	300	300		p	Spalled Concrete
599	1000			c	Crack
600	500	300		p	Spalled Concrete
601	1300	700		p	Hollow / Delaminated
602	500	200		p	Hollow / Delaminated

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Contract Details:

Contract Ref:	SUR07603
Contract Name:	Sea Wall
Element:	East Face
Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
603	600	400		p	Spalled Concrete
604	1000			c	Crack
605	200	100		p	Hollow / Delaminated
606	150	100		p	Previous Repair
607	400	150		p	Previous Repair
608	600			c	Crack
609	800	300		p	Spalled Concrete
610	500	300		p	Hollow / Delaminated
611	300	150		p	Previous Repair
612	300	200		p	Previous Repair
613	1000			c	Crack
614	800			c	Crack
615	300	100		p	Previous Repair
616	400	300		p	Hollow / Delaminated
617	250	250		p	Spalled Concrete
618	1500	200		p	Previous Repair + Hollow / Delaminated
619	1000			c	Crack
620	300	150		p	Spalled Concrete
621	150	100		p	Spalled Concrete
622	400	200		p	Hollow / Delaminated
623	300	200		p	Spalled Concrete
624	2300			c	Crack
625	2500			c	Crack
626	2000			c	Crack
627	100	100		p	Hollow / Delaminated
628	300	150		p	Previous Repair
629	200	150		p	Previous Repair

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		Contract Ref:	SUR07603
		Contract Name:	Sea Wall
		Element:	East Face
		Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
630	400	300		p	Hollow / Delaminated
631	50	100		p	Spalled Concrete
632	200	150		p	Spalled Concrete
633	500			c	Crack
634	1000			c	Crack
635	1000			c	Crack
636	250	250		p	Previous Repair
637	150	150		p	Previous Repair
638	300	150		p	Previous Repair
639	2500	150		s	Degraded Pyritous Aggregates
640	400	400		p	Spalled Concrete
641	2000			c	Crack
642	100	50		p	Spalled Concrete
643	150	50		p	Spalled Concrete
644	300	200		p	Hollow / Delaminated
645	1000			c	Crack
646	1500			c	Crack
647	1700			c	Crack
648	100	100		p	Hollow / Delaminated
649	1200	700		p	Hollow / Delaminated
650	1000			c	Crack
651	1200			c	Crack
652	2500			c	Crack or Joint
653	1000			c	Crack
654	2000			c	Crack
655	250	100		p	Spalled Concrete
656	500	400		p	Hollow / Delaminated
657	2000			c	Crack
658	1500	200		p	Previous Repair
659	1000	50		p	Previous Repair
660	800	200		p	Previous Repair
661	500	300		p	Spalled Concrete
662	150	150		p	Spalled Concrete
663	100	50		p	Spalled Concrete
664	50	50		p	Spalled Concrete
665	100	100		p	Spalled Concrete
666	100	100		p	Spalled Concrete
667	200	100		p	Spalled Concrete
668	100	50		p	Spalled Concrete
669	1800			c	Crack

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Contract Details:

Contract Ref:	SUR07603
Contract Name:	Sea Wall
Element:	East Face
Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
670	2000			c	Crack
671	300	200		p	Spalled Concrete
672	2000			c	Crack
673	300	300		p	Spalled Concrete
674	800			c	Crack
675	1000			c	Crack
676	1000	1000		p	Spalled Concrete
677	500	200		p	Previous Repair
678	500	200		p	Previous Repair
679	400	300		p	Hollow / Delaminated
680	300	150		p	Spalled Concrete
681	50	50		p	Spalled Concrete
682	150	100		p	Spalled Concrete
683	1000			c	Crack
684	1000			c	Crack
685	500	200		p	Spalled Concrete
686	1000			c	Crack
687	200	100		p	Spalled Concrete
688	300	300		p	Hollow / Delaminated
689	400	200		p	Spalled Concrete
690	500	300		p	Spalled Concrete
691	2000			c	Crack
692	1000			c	Crack
693	1500			c	Crack
694	100	100		p	Hollow / Delaminated
695	1200			c	Crack
696	1200			c	Crack
697	2500			c	Crack
698	300	200		p	Hollow / Delaminated
699	400	100		p	Hollow / Delaminated
700	50	50		p	Spalled Concrete
701	300	200		p	Spalled Concrete
702	200	100		p	Spalled Concrete
703	500	400		p	Spalled Concrete
704	300	150		p	Spalled Concrete
705	400	300		p	Spalled Concrete
706	500	200		p	Previous Repair
707	300	100		p	Spalled Concrete
708	300	200		p	Hollow / Delaminated
709	200	100		p	Previous Repair

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Contract Details:	
Contract Ref:	SUR07603
Contract Name:	Sea Wall
Element:	East Face
Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
710	100	100		p	Hollow / Delaminated
711	300	200		p	Previous Repair
712	1800	1500		p	Hollow / Delaminated
713	300	100		p	Spalled Concrete
714	200	200		p	Spalled Concrete
715	200	100		p	Spalled Concrete
716	5000	500		p	Previous Repair
717	7200	600		p	Previous Repair
718	300	150		p	Hollow / Delaminated
719	150	50		p	Hollow / Delaminated

10.2 DEFECTS SCHEDULE – WEST FACE / PARAPET WALL

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Contract Details:

Contract Ref:	SUR 07603
Contract Name:	Sea Wall
Element:	West Face
Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
1	500	200		p	Hollow / Delaminated
2	1200	600		p	Hollow / Delaminated
3	400	400		p	Hollow / Delaminated
4	500	100		p	Hollow / Delaminated
5	1000	150		p	Hollow / Delaminated
6	400	150		p	Hollow / Delaminated
7	400	400		p	Hollow / Delaminated
8	500	300		p	Hollow / Delaminated
9	400	300		p	Hollow / Delaminated
10	200	200		p	Hollow / Delaminated
11	400	300		p	Hollow / Delaminated
12	500	100		p	Previous Repair
13	600	300		p	Previous Repair
14	1200	400		p	Hollow / Delaminated
15	1000	600		p	Hollow / Delaminated
16	100	100		p	Hollow / Delaminated
17	1200	400		p	Hollow / Delaminated
18	1600	400		p	Hollow / Delaminated
19	600	200		p	Hollow / Delaminated
20	800	600		p	Hollow / Delaminated
21	1000	300		p	Hollow / Delaminated
22	1800	500		p	Hollow / Delaminated
23	1500	400		p	Hollow / Delaminated
24	200	100		p	Hollow / Delaminated
25	1100	300		p	Hollow / Delaminated
26	600	300		p	Hollow / Delaminated
27	600	400		p	Hollow / Delaminated
28	400	700		p	Hollow / Delaminated
29	200	300		p	Hollow / Delaminated
30	500	400		p	Hollow / Delaminated
31	700	1300		p	Hollow / Delaminated
32	400	200		p	Hollow / Delaminated
33	600	400		p	Hollow / Delaminated
34	500	400		p	Hollow / Delaminated
35	1000	600		p	Previous Repair
36	150	150		p	Hollow / Delaminated
37	1000	300		p	Previous Repair
38	150	150		p	Hollow / Delaminated
39	500	500		p	Hollow / Delaminated
40	1000	1300		p	Hollow / Delaminated

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	Contract Name:	Sea Wall
	Element:	West Face
	Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
41	200	200		p	Hollow / Delaminated
42	200	300		p	Hollow / Delaminated
43	1000	1500		p	Hollow / Delaminated
44	500	500		p	Hollow / Delaminated
45	800	200		p	Hollow / Delaminated
46	1000	900		p	Previous Repair
47	300	600		p	Previous Repair
48	200	300		p	Hollow / Delaminated
49	1000	700		p	Hollow / Delaminated
50	500	500		p	Previous Repair
51	500	150		p	Hollow / Delaminated
52	500	100		p	Hollow / Delaminated
53	600	100		p	Hollow / Delaminated
54	300	300		p	Previous Repair
55	350	350		p	Hollow / Delaminated
56	500	300		p	Hollow / Delaminated
57	400	300		p	Hollow / Delaminated
58	1000	3700		p	Hollow / Delaminated
59	400	500		p	Hollow / Delaminated
60	800	800		p	Hollow / Delaminated
61	150	150		p	Hollow / Delaminated
62	500	500		p	Hollow / Delaminated
63	600	600		p	Previous Repair
64	1000	1000		p	Hollow / Delaminated
65	200	200		p	Hollow / Delaminated
66	500	150		p	Hollow / Delaminated
67	1000	200		p	Hollow / Delaminated
68	900	1100		p	Hollow / Delaminated
69	150	150		p	Hollow / Delaminated
70	200	300		p	Hollow / Delaminated
71	1200	1000		p	Hollow / Delaminated
72	300	300		p	Previous Repair
73	300	300		p	Previous Repair
74	400	300		p	Hollow / Delaminated
75	1600	300		p	Hollow / Delaminated
76	1000	150		p	Hollow / Delaminated
77	400	300		p	Hollow / Delaminated
78	200	200		p	Hollow / Delaminated
79	500	400		p	Hollow / Delaminated
80	150	300		p	Spalled Concrete

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Contract Details:	
Contract Ref:	SUR 07603
Contract Name:	Sea Wall
Element:	West Face
Date:	Jun-07

Schedule of Dilapidations / Defects:

Defect Type: a = arris p = patch c = crack s = surface

No	Approximate Dimensions, mm			Defect Type	Description
	Length	Width/Girth	Depth		
81	150	150		p	Hollow / Delaminated
82	600	300		p	Spalled Concrete
83	150	250		p	Hollow / Delaminated
84	300	300		p	Spalled Concrete
85	500	500		p	Hollow / Delaminated
86	1200	1800		p	Spalled Concrete
87	2000	2000		p	Spalled Concrete
88	2000	1800		p	Spalled Concrete
89	1600	2000		p	Spalled Concrete
90	1900	300		p	Spalled Concrete
91	2100	600		p	Spalled Concrete
92	1900	600		p	Spalled Concrete
93	200	200		p	Spalled Concrete
94	200	200		p	Spalled Concrete
95	400	400		p	Spalled Concrete
96	500	200		p	Hollow / Delaminated
97	800			c	Crack
98	800			c	Crack
99	800			c	Crack

11. APPENDIC D: CRL - EXPLORATORY BREAKING OUT

Very Badly Corroded 10mm Horizontal Bar

SITE	DETAILS`	DATE	CONTRACT NO.	INTIALS
Sea Wall	Break-out 1	June 2007	SUR07603	GN

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Surface Corrosion on the 2mm Mesh in the Previous Repair Patch

SITE	DETAILS`	DATE	CONTRACT NO.	INTIALS
Sea Wall	Break-out 2	June 2007	SUR07603	GN

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Cathite House, 23a Willow Lane
Mitcham, Surrey, CR4 4TU
Tel: 0208 288 4848
Fax: 0208 288 4847
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Break-out at Rust Stain to Reveal Degraded Pyritous Aggregates Particle .

SITE	DETAILS`	DATE	CONTRACT NO.	INTIALS
Sea Wall	Break-out 3	June 2007	SUR07603	GN

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Very Badly Corroded Vertical Bar.

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