

Sutton on Sea Colonnade

Concrete Testing

East Lindsey District Council

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Quality information

Prepared by

Mark Evans
Senior Assistant Engineer

Checked by

Pete Hemsley
Principle Engineer

Approved by

Lucy Moore
Associate

Revision History

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Prepared for:

East Lindsey District Council

Prepared by:

AECOM Infrastructure & Environment UK Limited
Royal Court
Basil Close
Derbyshire
Chesterfield
S41 7SL
UK

T: +44 (1246) 209221
aecom.com

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1. Introduction

AECOM has been appointed by East Lindsey District Council to carry out a Special Inspection and non-destructive testing of Sutton on Sea Colonnade.

The non-destructive testing comprised;

- Corrosion Potential Survey (Half-Cell)
- Resistivity Survey
- Extraction of Dust Samples for Chloride Ion Analysis
- Carbonation Depth
- Cover Meter Survey

2. Testing Procedure

Testing was carried out in the following locations;

<u>Test area</u>	<u>Location</u>
1	Adjacent to column EE – see Figure 3 and drawings 001 and 002
2	Adjacent to column AA – see Figure 4 and drawings 003 and 004
3	Adjacent to column BB – see Figure 5 and drawings 005 and 006
4	Adjacent to column U – see Figure 6 and drawings 007 and 008
5	Adjacent to column K – see Figure 7 and drawings 009 and 010
6	At the half joint between columns G-H – see Figure 8 and drawing 011
7	On the front beam between columns J-K – see drawing 012

Refer to Figure 01 and 02 for the location of the test areas.

Testing was carried out to the full height of the back wall, 1m either side of the transverse beams at 500mm centres, the same applies to the soffit. The centre of each face of the transverse beam and front beam were also tested for half-cell reading.

Test areas 2, 3, 6 and 7 were chosen as these areas are in poor condition with exposed reinforcement and rust staining noted. Areas 1, 4 and 5 were in areas in good condition, with no rust staining, spalling or obvious defects noted, and were chosen to determine a base reading of the structure.

The method of testing is as described in Appendix A.

3. Findings

Test area 1

An unknown paint system is applied to all areas of the test panel generally masking the condition of the concrete behind. In places the coating is peeling, mainly on the soffit and transverse beams, in these areas there are blowholes within the concrete due to poor compaction during construction. There is an area of exposed reinforcement in the soffit to the northern side of the test area which appears due to a combination of low cover and carbonation. There are also several areas of rust staining in the soffit.

Back wall

There are medium chloride levels at reinforcement depth (0.071% by weight of concrete), with steep gradients in half-cell readings towards the interface with the soffit suggesting that corrosion maybe occurring although there is no visible evidence.

The cover to reinforcement is mainly good, there are isolated areas of low cover (minimum cover 24mm), however carbonation is at the depth of the reinforcement in places (23mm) indicating that carbonation induced corrosion of the reinforcement may already be an issue.

The resistivity readings (minimum 128.4 kΩcm) could be artificially high due to the depth of carbonation.

Soffit

There are high levels of chlorides at reinforcement depth (0.212% by weight of concrete) along with large negative half-cell readings, with some steep gradients suggesting that corrosion maybe occurring, indicating that the corrosion in the soffit is more wide spread than the areas of exposed reinforcement.

There is relatively low cover to reinforcement (minimum cover 15mm), although carbonation is deep (11mm) and it has yet to reach the reinforcement depth exposed reinforcement in the soffit appeared to be suffering from carbonation induced corrosion.

The resistivity readings (minimum 111.2 kΩcm) could be artificially high due to the depth of carbonation.

Transverse Beam

Low chloride levels at reinforcement depth (0.036% by weight of concrete) with large negative half-cell readings, with some steep gradients suggesting that corrosion maybe occurring, although there is no visual evidence.

The cover to reinforcement is low (minimum cover <14mm), there is significant depth of carbonation (8mm) suggesting that carbonation induced corrosion of the reinforcement may be an issue.

The resistivity readings (minimum 128.0 kΩcm) could be artificially high due to the depth of carbonation.

Front Beam

Insignificant chloride levels at reinforcement depth (0.014% by weight of concrete) but large negative half-cell readings, with some steep gradients suggesting that corrosion maybe occurring, although there is no visual evidence.

The cover to reinforcement is relatively low (minimum cover 21mm); there are significant depths of carbonation (19mm) suggesting that carbonation induced corrosion of the reinforcement may already be an issue.

The resistivity readings (minimum 128.3 kΩcm) could be artificially high due to the depth of carbonation.

Overall the concrete in this area in this area is in poor condition with both chloride and carbonation penetration an issue, this suggests that a relatively low quality concrete was used in the construction.

Test area 2

An unknown paint system is applied to all areas of the test panel generally masking the condition of the concrete behind. The beam above the steps has areas of delamination and rust staining noted along its length. There is an area of exposed reinforcement to the northern side of the transverse beam in the soffit which appears to have been caused by low cover and carbonation.

Back wall

The half-cell readings are inconclusive; although relatively high there are no steep gradients suggesting that corrosion is unlikely to be occurring, and no visible evidence of on-going corrosion.

The cover to reinforcement is generally good (minimum cover 52mm).

Soffit

Chloride levels are low at reinforcement depth (0.049% by weight of concrete), the half-cell readings are generally inconclusive, however there are some steep gradients adjacent to the transverse beam, suggesting that corrosion maybe occurring, this may suggest that corrosion of the transverse is more wide spread than the exposed area of reinforcement.

The cover to reinforcement is low (minimum cover <14mm), there is significant depth of carbonation (8mm) suggesting that carbonation induced corrosion of the reinforcement may be an issue.

The resistivity readings (minimum 16.3 kΩcm) show there is a possible moderate to low risk of corrosion of reinforcement.

Beam above stairway

Medium level of chloride levels at reinforcement depth (0.085% by weight of concrete) half-cell readings are high and although there are no steep gradients between half-cell readings suggesting that corrosion is unlikely to be occurring, the beam has areas of delamination and rust staining along its length showing that corrosion is occurring.

There is low cover to reinforcement (minimum cover 19mm), and carbonation has yet to reach the depth of reinforcement (9mm) indicating that carbonation induced corrosion of the reinforcement will not be an issue.

The resistivity readings (minimum 11.9 kΩcm) show there is a moderate to low risk of possible corrosion of reinforcement.

Transverse beam

There are medium levels of chlorides at reinforcement depth (0.056% by weight of concrete), along with large negative half-cell readings, with some steep gradients suggesting that corrosion maybe occurring, spalling is present in the beam, the half celling reading indicate that corrosion maybe more widespread.

The cover is low to reinforcement (minimum cover <14mm), and carbonation is at the depth of the reinforcement (16mm) indicating that carbonation induced corrosion of the reinforcement may already be an issue, this agrees with the visual findings on site that reinforcement corrosion is due to carbonation.

The resistivity readings (minimum 42.1 kΩcm) could be artificially high due to the depth of carbonation.

Front beam

There are medium levels of chlorides at reinforcement depth (0.071% by weight of concrete), although the half-cell readings are relatively low with no steep gradients suggesting that corrosion is unlikely to be occurring, there is no visible evidence of corrosion occurring.

The cover to reinforcement is low (minimum cover 17mm), apart from on the soffit, where carbonation is at the depth of the reinforcement (18mm) indicating that carbonation induced corrosion of the reinforcement may already be an issue.

The resistivity readings (minimum 36.7 kΩcm) could be artificially high due to the depth of carbonation.

Overall the concrete in this area in this area is in poor condition with both chloride and carbonation penetration an issue, this suggests that a relatively low quality concrete was used in the construction. From the visual inspection and the testing resulting the spalling on the transverse beam is due to carbonation.

Test area 3

An unknown paint system has been applied to all the concrete surfaces in the test area masking the condition of the concrete behind. The coating is failing on the soffit and transverse beam, in these areas there is surface blowholes and honeycombing. There are several areas of exposed reinforcement in the south side of the soffit, which is due to a combination of low cover and carbonation. There are several areas of rust staining within the soffit and the transverse beam. Water staining is also present at the east end of the transverse beam.

Back wall

There are medium levels of chlorides at reinforcement depth (0.099% by weight of concrete) and half-cell readings with suggesting that corrosion maybe occurring, although there is no visible evidence.

There is deep carbonation (28mm); however it has not reached the depth of reinforcement (minimum cover 92mm) indicating that carbonation induced corrosion of the reinforcement will not be an issue.

The resistivity reading (minimum 9.8 kΩcm) indicates that there is a high possible risk of reinforcement corrosion.

Soffit

There are medium levels of chlorides at reinforcement depth (0.071% by weight of concrete) and half-cell readings, with steep gradients between nodes, suggesting that corrosion maybe occurring, indicating that reinforcement corrosion is over a larger area than the areas of exposed reinforcement.

There is low cover to reinforcement throughout (minimum cover <14mm) and carbonation (10mm) is almost at the depth of the reinforcement although the carbonation front has yet to reach the depth of reinforcement, exposed reinforcement in the soffit appeared to be suffering from carbonation induced corrosion.

The resistivity reading indicates (minimum 16.2 kΩcm) that there is a moderate to low possible risk of possible corrosion of reinforcement.

Transverse beam

High chloride levels at reinforcement depth in the transverse beam (0.283% by weight of concrete); the half-cell readings are high, suggesting that corrosion may be occurring, indicating that reinforcement corrosion is over a larger area than the areas of rust staining.

The carbonation (>35mm) has reached the depth of reinforcement (minimum cover <14mm) indicating that carbonation induced corrosion of the reinforcement may already be occurring.

The resistivity reading (minimum 1.9 kΩcm) indicates that there is a very high possible risk of possible corrosion of reinforcement.

Front beam

Medium chloride levels at reinforcement depth (0.071% by weight of concrete), the half-cell readings are high with some steep gradients, suggesting that corrosion maybe occurring, although there is no visible evidence.

The carbonation (>34mm) has reached the depth of reinforcement (minimum cover 23mm) indicating that carbonation induced corrosion of the reinforcement may already be occurring.

The resistivity reading (minimum 128.6 kΩcm) indicates that there is an insignificant risk of possible corrosion rate of reinforcement, however the reading could be artificial high due to the deep carbonation.

Overall the concrete in this area in this area is in poor condition with both chloride and carbonation penetration an issue, this suggests that a relatively low quality concrete was used in the construction.

Test area 4

An unknown paint system has been applied to all the concrete surfaces in the test area masking the condition of the concrete behind. The coating is generally in good condition, however there are areas of failure in the soffit, in these areas the concrete has surface blowholes and honeycombing. There is a large area of exposed reinforcement in the soffit to the south side of the transverse beam, due to a combination of low cover and carbonation. There is also 1no. area of rust staining in the soffit, at the south side of the transverse beam.

Back Wall

Insignificant chloride levels at reinforcement depth ($<0.003\%$ by weight of concrete), the half-cell readings are high, with, suggesting that corrosion maybe occurring, although there is no visible evidence.

The cover to reinforcement (minimum cover 86mm) is high and carbonation (17mm) has not reached the depth of reinforcement indicating that carbonation induced corrosion of the reinforcement is unlikely be an issue.

The resistivity readings (minimum 19.2 kΩcm) show there is a moderate to low risk of possible corrosion rate of reinforcement.

Soffit

High chloride levels at reinforcement depth (0.248% by weight of concrete), there are also some steep gradients in the half-cell readings' suggesting that corrosion maybe occurring..

Cover to reinforcement is low (minimum cover $<14\text{mm}$) and carbonation (18mm) has gone past the depth of reinforcement indicating that carbonation induced corrosion of the reinforcement may already be an issue, this is backed up by spalling exposing the reinforcement that is suffering from carbonation type corrosion.

The resistivity readings (minimum 17.9 kΩcm) show there is a moderate to low risk of possible corrosion of reinforcement.

Transverse beam

There are medium levels of chlorides at reinforcement depth (0.071% by weight of concrete), there are steep gradients between nodes of the half-cell readings, suggesting that corrosion maybe occurring, and corrosion in the soffit may also have spread into the beam.

The cover to reinforcement is low (minimum cover $<14\text{mm}$) and carbonation (22mm) has gone past the depth of the reinforcement indicating that carbonation induced corrosion of the reinforcement may already be occurring.

The resistivity readings (minimum 128.6 kΩcm) could be artificially high due to the depth of carbonation.

Front beam

Low chloride level at reinforcement depth (0.021% by weight of concrete), and half-cell readings suggesting that corrosion is unlikely to be occurring, there is no visible evidence of corrosion occurring.

The cover to reinforcement is low (minimum cover 20mm) but carbonation (26mm) has gone past the depth of the reinforcement indicating that carbonation induced corrosion of the reinforcement may already be an issue.

The resistivity readings (minimum 105.0 kΩcm) could be artificially high due to the depth of carbonation.

Overall the concrete the concrete in the back wall is in good condition with no immediate risk of reinforcement corrosion. Concrete in the remaining test areas is in poor condition with both chloride and carbonation penetration an issue, this suggests that a relatively low quality concrete was used in the construction. The visual inspection and test results agree that spalling is due to carbonation.

Test area 5

An unknown paint system has been applied to all the concrete surfaces in the test area masking the condition of the concrete behind, the coating is in good condition with no areas of failure noted. There are several isolated areas of minor rust staining noted within the soffit. There is a spall in the column exposing the reinforcement, due to a combination of low cover and carbonation.

Back wall

There are low chloride levels at reinforcement depth (0.007% by weight of concrete), however there are large negative half-cell readings with steep gradients between nodes, suggesting that corrosion maybe occurring, although there is no visible evidence. Readings at the bottom of the test area are more negative than the readings at the top which have been caused by ground water penetration.

Cover to reinforcement is generally moderate (minimum cover 27mm) with carbonation (10mm) not reaching the depth of reinforcement indicating that carbonation induced corrosion of the reinforcement is unlikely be an issue.

The resistivity readings (minimum 10.8 kΩcm) indicate that there is a moderate to low risk of possible corrosion of reinforcement. The resistivity reading at the bottom of the panel is significant lower than the reading at the top of the panel which suggest that ground water penetration is occurring.

Soffit

There are high chlorides levels at reinforcement depth (0.170% by weight of concrete), with large negative half-cell readings. Cracking with rust staining along with the large gradient in half-cell readings around the crack indicates that corrosion is already occurring.

Cover to reinforcement is low throughout (minimum cover <14mm), however carbonation (5mm) has not reached the depth of reinforcement indicating that carbonation induced corrosion of the reinforcement is unlikely to be a problem at present.

The resistivity readings (minimum 12.6 kΩcm) indicate that there is a moderate to low risk of possible corrosion of reinforcement.

Front beam

There are medium chloride levels at reinforcement depth (0.142% by weight of concrete), half-cell readings are moderate with some steep gradients suggesting that corrosion maybe occurring.

Cover to reinforcement is low (minimum cover 16mm) however carbonation (6mm) has not reached the depth of reinforcement indicating that carbonation induced corrosion of the reinforcement will not be an issue at present.

The resistivity readings (minimum 4.5 kΩcm) indicate that there is a high risk of possible corrosion of reinforcement.

Column

There are medium chloride levels at reinforcement depth (0.071% by weight of concrete), half-cell readings are low but there are steep gradients at the top of the column suggesting that corrosion maybe occurring, as confirmed by the spalling at the top of the column.

Cover to reinforcement is reasonable (minimum cover 26mm) and carbonation where measured (10mm) has not reached the depth of reinforcement, however corrosion to the reinforcement at the top of the column exposed by the spalling visually appears to be due to carbonation.

The resistivity readings (minimum 85.2 kΩcm) could be artificially high due to the depth of carbonation.

Overall the concrete in the back wall is in good condition with no immediate risk of reinforcement corrosion. The remaining areas in the test panel are in poor condition with chloride penetration an issue.

Test area 6

An unknown paint system has been applied to all the concrete surfaces in the test area masking the condition of the concrete behind. The northern side of the joint is visually in good condition however the southern side has a 2no. large areas of spalling, which are exposing the reinforcement.

The chloride levels at the south side of the joint are medium at reinforcement depth (0.071% by weight of concrete), with high half-cell readings both side, with steep gradients noted, suggesting that corrosion maybe occurring, as confirmed by the spalling noted.

Cover to reinforcement is low (minimum <14mm) and carbonation (18mm) is at the depth of the reinforcement indicating that carbonation induced corrosion of the reinforcement may already be an issue.

Overall the concrete in this area in this area is in poor condition with both chloride and carbonation penetration an issue, this suggests that a relatively low quality concrete was used in the construction.

Test area 7

An unknown paint system has been applied to all the concrete surfaces in the test area masking the condition of the concrete behind. There is a rusting staining emanating from a crack in the front face of the beam, indicating that corrosion is occurring.

No cover meter readings were taken, cover meter readings taken at test area 5 show that the cover on the front beam is 16mm so is assumed to be similar at this test location. The chlorides levels taken are medium at reinforcement level (0.071% by weight of concrete), suggesting there is no risk of chloride immediate risk induced corrosion, which suggests that corrosion is due to carbonation.

4. Discussion

The back wall visually is in good condition and this borne out by the results of the testing undertaken. Although there are some large negative half-cell potentials recorded, the potential differences between adjacent nodes are low, which is indicative that corrosion is unlikely to be occurring. The relatively high depth of cover, found on the back wall sections, may influence the half-cell measurement, but will also provide increased protection to the reinforcement, with carbonation induced corrosion of the reinforcement unlikely to occur within the lifespan of the structure.

The carbonation results for the soffit, transverse beams and front beam show that the carbonation front has reached close to and beyond the depth of reinforcement in several areas. The exposed reinforcement around the structure has a general surface corrosion associated with carbonation rather than been pitted which is associated with chloride induced corrosion.

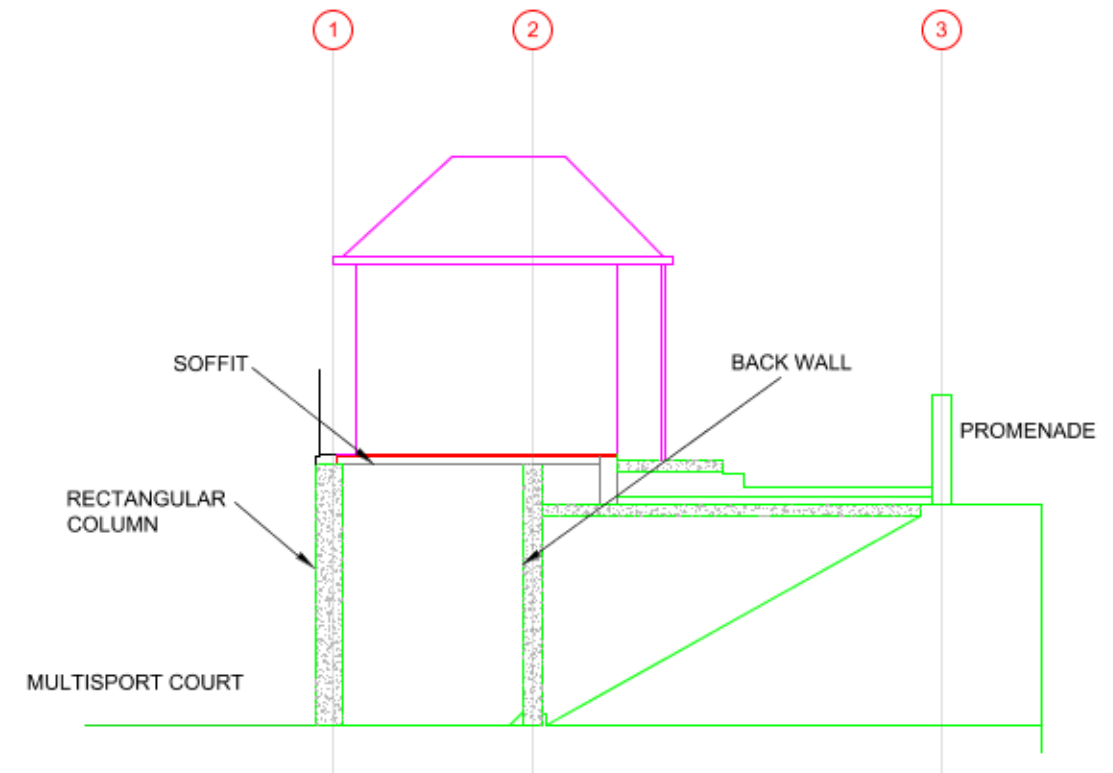
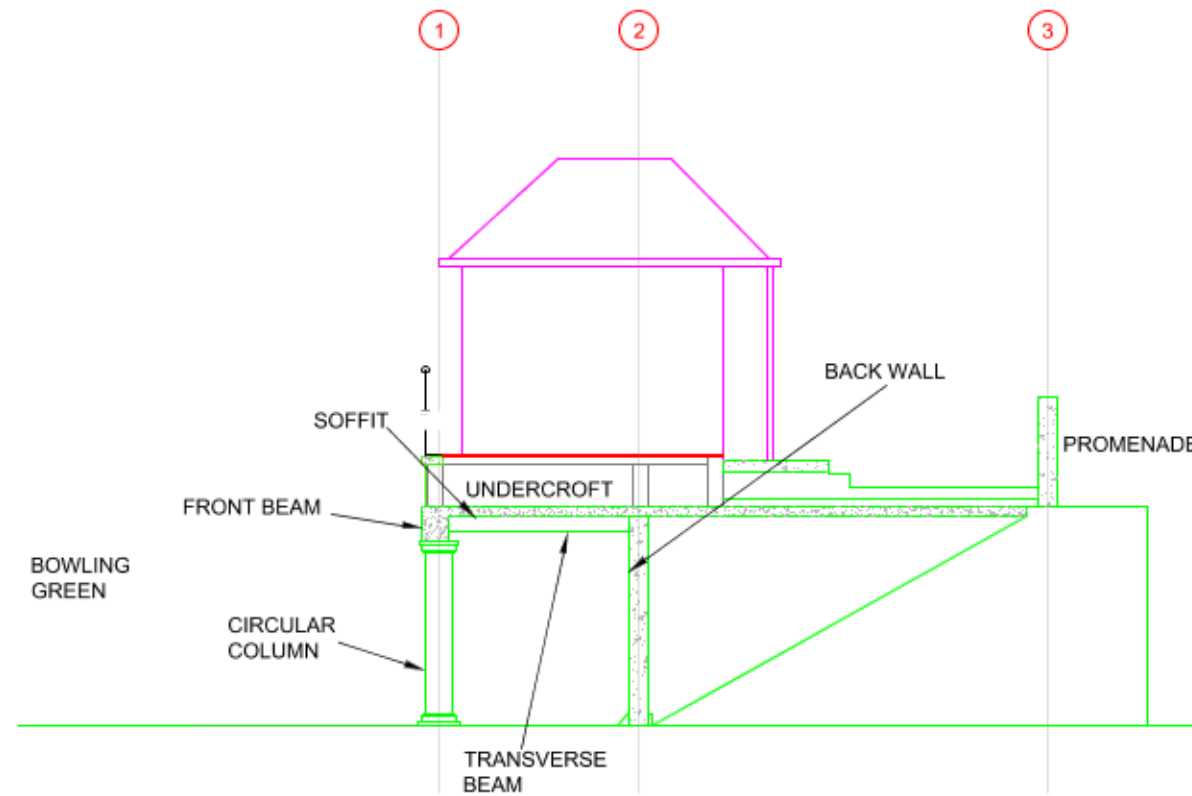
The half-cell readings for the soffit, transverse beams are all large negative readings with <100mV differences between adjacent readings indicating that corrosion is also occurring in areas where spalling and exposed reinforcement is not already visible.

Chloride levels at reinforcement level generally indicate a moderate risk of chloride induced damage to the reinforcement, however as mention previously corrosion is thought to be due to carbonation, however if left chloride induced corrosion could potentially occur.

The main reason for the defects to the structure is thought to be poor quality of concrete workmanship during construction of the structure, with the soffit, transverse beam and front beam especially having areas of low cover (less than 14mm). There are also areas of blowholes and honeycombing.


Appendix A Figures

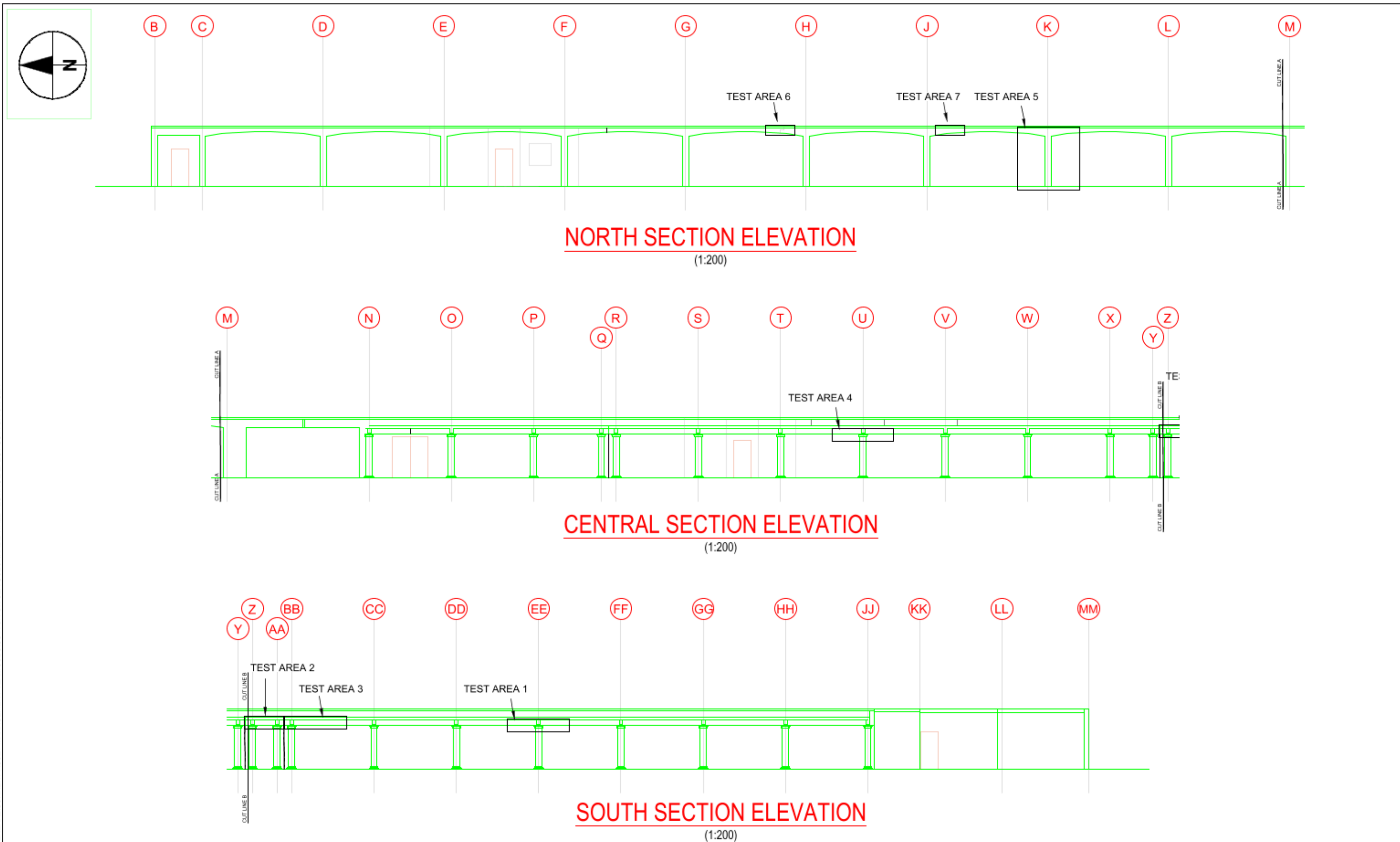
Plot Date : 17 July 2018 16:58:36
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Appendix B Testing and Interpretation of results

TESTING AND INTERPRETATION OF RESULTS

TESTING

Testing is in accordance with the following Highways England's Departmental Standard and Advice Notes, varied to suit the client's requirements, the particular structure and condition where appropriate:-

BA35 Inspection and Repair of Concrete Highway Structures

BD43 Criteria and Materials for the Impregnation of Concrete Highway Structures

The following tests are performed by AECOM Infrastructure and Environment UK Ltd (AECOM).

AECOM are UKAS accredited to carry out the following tests (a schedule of accreditation is included in this section):-

Corrosion Potential Survey (Half-Cell)

Resistivity Survey

Extraction of Dust Samples for Chloride Ion Analysis

Carbonation Depth

Cover Meter Survey

Areas Tested

The areas tested were selected generally in accordance with the above standards. Potential high risk areas were taken to be those where there was evidence of deterioration or leakage from a deck joint above. Testing of splash zones concentrated on areas adjacent to the low side of the carriageway where salt-laden water would accumulate, within 8m of the carriageway. Areas were extended and/or joined together, where desirable/practical, to give an overall picture.

All concrete testing is completed in accordance with Test Procedures TP/STRUCT 01-06 inclusive found in Appendix A, of the Site Laboratory Quality Manual. This is part of the Quality Assurance System.

Corrosion Potential (Half-Cell) Survey

Corrosion Potential measurement surveys are either carried out in accordance with Test Procedure TP/STRUCT 01 which is in accordance with ASTM C876-15, or Test Procedure TP/STRUCT 06 which is in accordance with TRRL Application Guide 9. Temperature readings are taken but coefficients are not applied to the half-cell corrosion potential readings, unless requested by the client. Temperature adjustments have a minimal effect on corrosion potential readings, typically 1mV per °C either side of the norm of 22 °C.

The equipment used are a SCRIBE DHC (Digital Half-Cell) manufactured by CMT (Instruments) Ltd, Derby (now Proceq), DHC (Digital Half-Cell) manufactured by Hammond Concrete, or the Elcometer Instruments 331BH. The CMT & Hammond Concrete instruments have a silver/silver chloride mapping electrode and the internal electronics have been modified to display equivalent copper/copper sulphate readings. The Elcometer instrument displays silver/silver chloride potentials which require adjusting to report as equivalent copper/copper sulphate readings (the industry standard).

Resistivity Survey

Resistivity measurement surveys of the concrete were carried out in accordance with Test Procedure TP/STRUCT 02 which is based on the technique described in the manufacturer's operating instructions.

The equipment used was a SCRIBE DRAM (Digital Resistivity Array Meter) manufactured by CMT (Instruments) Ltd, Derby.

Chloride Ion Analysis

Dust samples were collected in accordance with Test Procedure TP/STRUCT 03 which is based on the technique described in Transport Research Laboratory (TRL) Contractor Report No 32. The samples were then sent for analysis to a UKAS accredited testing laboratory. The dust samples were analysed by potentiometric titration in accordance with BS 1881 Part 124: 1988.

Carbonation Survey

Carbonation surveys were carried out in accordance with Test Procedure TP/STRUCT 04 which is based on the technique described in BS EN 14630: 2006.

The indicator solution used was to the following specification:-

Phenolphthalein 1% solution in aqueous ethanol for pH range 8.3 - 10.0.

Cover Survey

Cover surveys were carried out in accordance with Test Procedure TP/STRUCT 05 which is in accordance with BS 1881 Part 204:1988.

Calibration of Instruments

All instruments used for Structures Testing are maintained and calibrated in accordance with procedures listed in Appendix A, of the Site Laboratory Quality Manual.

INTERPRETATION OF RESULTS

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation. The boundary values given in this appendix offer a general guide only and should not be treated as absolute. No, one, test result should be considered in isolation, experience / engineering judgement should be applied and consideration given to all available test results and visual inspection of the areas tested, as well as the situation and the use of the structure.

Guidance on the interpretation of test results, with particular reference to the suitability of a structure for impregnation, is given in the following Highways England's Departmental Standard and Advice Notes, varied to suit the particular structure and condition where appropriate:-

BA35 Inspection and Repair of Concrete Highway Structures

BD43 Criteria and Materials for the Impregnation of Concrete Highway Structures

The results are summarised on a modified version of Figure A1.1 from BD43 reproduced in this appendix as Figure C1. The classifications are as follows:-

- Good - Low risk of chloride induced corrosion and a low/uncertain risk of corrosion activity (Impregnate)
- Fair - Medium to high risk of chloride induced corrosion, but low to uncertain risk of corrosion activity (corrosion may not yet be initiated). (Impregnate & monitor)
- Poor - Medium to high risk of chloride induced corrosion, (see following table), but a high risk of corrosion activity. (Conduct further, intrusive, investigations in to the condition of the reinforcement, prior to finalising recommendations)
- Uncertain - Low risk of chloride induced corrosion, but the corrosion potential readings (used to determine the risk of corrosion activity) have likely been distorted by external factors, (such as surface contaminants, moisture on the surface or within the concrete, or stray electrical currents).

Corrosion Potential Survey

Measuring corrosion potentials gives an indication of the risk of reinforcement being corrosively active.

Probability criteria for the readings which the instrument produces are in accordance with ASTM C876-15.

Potential (mV vs. Cu/CuSO ₄)	Risk of reinforcement being corrosively active
More negative than -350	>90%
-200 to -350	Uncertain
Less negative than -200	<10%

NOTE Temperature coefficients have not been applied to the half-cell readings.

Resistivity Survey

Measuring the resistivity of concrete gives an indication of the likely rate of reinforcement corrosion.

The probability criteria for possible rate of corrosion are reproduced from the manufacturer's literature below:-

Resistivity (kΩcm)	Possible corrosion rate of reinforcement
<5	Very high
5 to 10	High
10 to 20	Moderate to Low
>20	Insignificant

Chloride Ion Analysis

Measurement of chloride ion content gives an indication of the risk of chloride induced damage to reinforcement.

The results have been quoted as percentage chloride ion by weight of concrete (as analysed), but have been plotted on Figure C1 as percentage chloride ion by weight of cement, assuming a cement content of 14%, unless tested. The chloride levels plotted on Figure C1 are those which pertain adjacent to the reinforcement. In addition to the level of 0.3% chloride ion by weight of cement used on Figure a1.1 of BD43 as the dividing line between Good and Fair areas, the following categories for risk of damage to reinforcement through chloride induced attack has been taken from the Concrete Society Technical Report No 26 and used to assist in the assessment of the condition of the structure.

Chloride by weight of concrete	Risk of chloride induced damage to reinforcement
<0.02%	Insignificant
0.02-0.05%	Low
0.05-0.15%	Medium
>0.15%	High

Chloride by weight of cement	Risk of chloride induced damage to reinforcement
<0.4%	Low
0.4 - 1.0%	Medium
>1.0%	High

Carbonation Survey and Cover to Reinforcement

Measurement of carbonation penetration depth gives an indication of the risk of damage to reinforcement due to de-alkalisation of the concrete. Carbonation is caused by a chemical reaction between atmospheric carbon dioxide and hydrated cement compounds. This reaction neutralises the alkaline cement paste which forms a passivating layer around the reinforcement. Concrete unaffected by carbonation with a pH value in excess of 10 shows red, whereas the affected concrete shows no colour change.

Factors influencing carbonation include:

- Duration of exposure to air
- Quality of hardened concrete
- Ambient exposure conditions
- Cracking in the concrete surface

The probability criteria for assessment of the time before cover to reinforcement is largely carbonated is approximately proportional to the square root of the time

$$\text{Depth of carbonation} = k \sqrt{\text{time}}$$

Where k is a constant depending on the properties of the concrete

If the age of the structure, the current depth of carbonation and the cover to the reinforcement are known, it is possible to estimate the time when the carbonation front will reach the reinforcement from the following formula:

$$T1 = T(c/x)^2$$

Where:

x = current depth of carbonation (mm)

c = cover (mm)

T = age of concrete in years

T1= period of initiation of corrosion in years


Unless carbonation depths are high, only % of the cover carbonated is normally reported.

Schedule of Accreditation

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Testing performed by the Organisation at the locations specified below		

Locations covered by the organisation and their relevant activities

Site activities performed away from the locations listed above:

Location details	Activity	Location code
<p>All locations suitable for the activities listed</p> <p>Ms L Moore Tel: +44 (0) 1246 209 221</p>	<p>Sampling: Concrete (hardened)</p> <p>Testing: Concrete (hardened) – chemical & non-destructive tests Concrete (reinforced) - non-destructive tests</p>	<p>Site</p>

 <p>1535 Accredited to ISO/IEC 17025:2005</p>	<p align="center">Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Slaines-upon-Thames, TW18 3HR, UK</p>
	<p align="center">AECOM Infrastructure & Environment Ltd Issue No: 014 Issue date: 04 January 2016</p>
<p align="center">Testing performed by the Organisation at the locations specified</p>	

DETAIL OF ACCREDITATION

Materials/Products tested	Type of test/Properties measured/Range of measurement	Standard specifications/ Equipment/Techniques used	Location Code
CONCRETE - hardened	Sampling of concrete by dust drilling Carbonation Resistivity	Documented In-House Method TP/STRUCT/03 based on TRL Contractor Report 32 BRE Information Paper IP 6/81 Documented In-House Method TP/STRUCT/02	Site
CONCRETE - reinforced	Location of reinforcement Half-cell potential of uncoated reinforcing steel in concrete Half-cell potential of uncoated reinforcing steel in concrete	BS 1881:Part 204:1988 ASTM C876-09 TRRL Applications Guide 9:1991	Site
END			

Appendix C Testing Results



TEST RESULTS

AECOM

1535

AECOM Office		CHESTERFIELD		Client	EAST LINDSEY DC
Structure Name		SUTTON-ON-SEA COLONNADE WALL			
Structure Number		S05	Site Survey Ref	23/5/18/01	
Date of Survey		23/05/18	Surveyed By	M EVANS	
Weather Conditions		OVERCAST	Signature		
Condition of Test Surface		DRY			
Temperature (°C)		12	Temperature Coefficient Applied to Results		NO
Connection Type		SCREW	Pre-wetted		YES

	Location 1 - Back Wall (SA)		Location 2 - Soffit (SB)	
	Depth (mm)	%	Depth (mm)	%
Chloride ion content % by weight of concrete	0-35	N/A	0-33	0.212
	35-52	N/A	33-50	0.355
	52-76	0.071	50-85	0.340
Depth of Carbonation (mm)	23		11	
Reinforcement Cover (mm)	24		15	
Resistivity (kΩ.cm) Minimum	128.5		111.2	
Note: Laboratory determination of chloride ion content is carried out by a separately accredited external organisation, not AECOM.				

SEE DRAWINGS 001 AND 002

	Location 3 - Transverse Beam (SD)		Location 4 - Front Beam (SD)	
	Depth (mm)	%	Depth (mm)	%
Chloride ion content % by weight of concrete	0-28	0.036	0-29	0.014
	28-47	0.036	29-53	0.036
	47-74	0.021	53-90	0.021
Depth of Carbonation (mm)	8		19	
Reinforcement Cover (mm)	<14		21	
Resistivity (kΩ.cm) Minimum	128.0		128.3	
Note: Laboratory determination of chloride ion content is carried out by a separately accredited external organisation, not AECOM.				

Structures Testing Manager's Signature	Test Area	TEST AREA 1	Around Column EE
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Location Sketch & Readings

> -200 = Half Cell Reading (mV)
(-123) = Half Cell Closing Reading (mV)

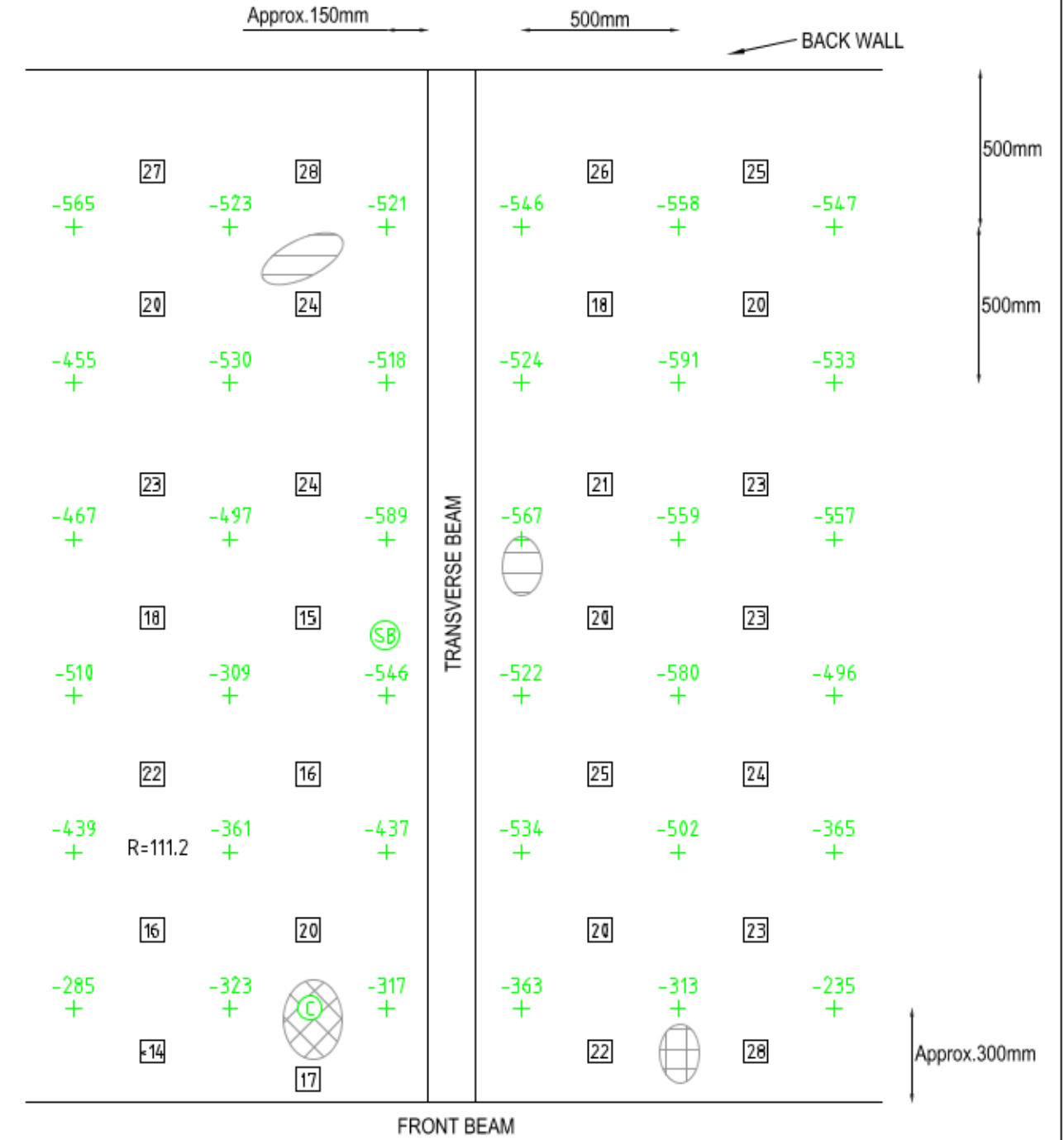
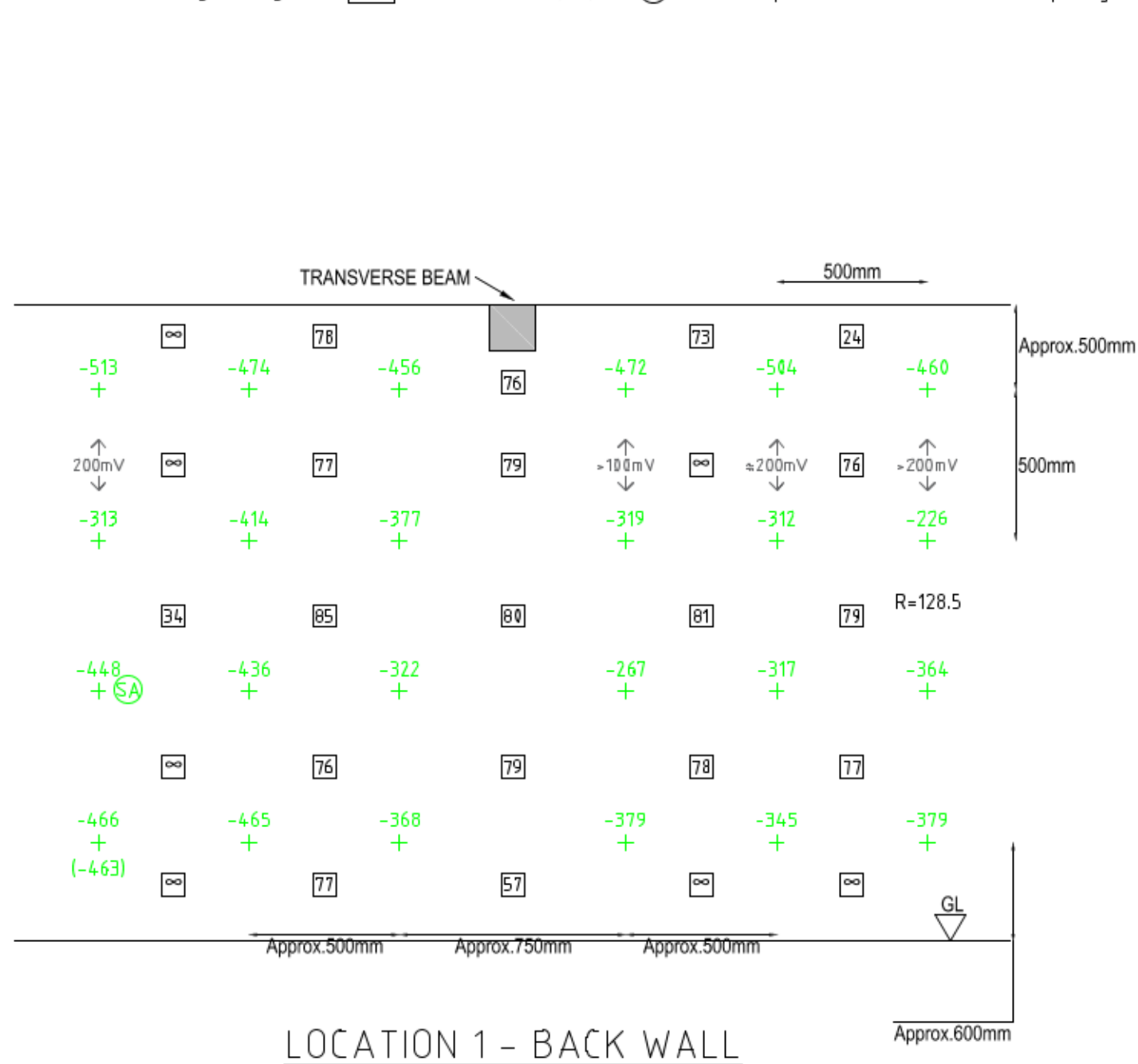
R=4.3 = Resistivity (kΩ.cm)
45 = Cover to Steel (mm)

⊕ = Corrosion Potential Connection
⊗ = Dust Sample Location


⊞ = Leakage
⊞ = Spalling

⊞ = Delamination
⊞ = Exposed Reinforcement

⊞ = Rust Staining



Plot Date : 17 July 2018 16:46:10
File Name : K:\03 INSPECTIONS\GENERAL\CURRENT ASSET MANAGEMENT TEAM JOBS\SUTTON ON SEA COLONNADE WALL TESTING\SUTTON-ON-SEA TA SKETCHES

<div>Project Title</div> <div>SUTTON-ON-SEA COLONNADE WALL 2018</div>	<div>Drawing Title</div> <div>CONCRETE TEST RESULTS TEST AREA 1 AT COLUMN EE</div>	<div>Purpose of issue</div> <div>-</div>					<div>THIS DOCUMENT HAS BEEN PREPARED PURSUANT TO AND SUBJECT TO THE TERMS OF AECOM'S APPOINTMENT BY ITS CLIENT. AECOM ACCEPTS NO LIABILITY FOR ANY USE OF THIS DOCUMENT OTHER THAN BY ITS ORIGINAL CLIENT OR FOLLOWING AECOM'S EXPRESS AGREEMENT TO SUCH USE, AND ONLY FOR THE PURPOSES FOR WHICH IT WAS PREPARED AND PROVIDED.</div>		<div>AECOM Infrastructure & Environment UK Limited</div> <div>Royal Court, Basil Close</div> <div>Chesterfield</div> <div>S41 7SL</div> <div>Tel: +44 (0)1246 209 221</div> <div>Fax: +44 (0)1246 209 229</div> <div>www.aecom.com</div> <div></div>	
		<div>Designed</div> <div>-</div>	<div>Drawn</div> <div>AS</div>	<div>Checked</div> <div>ME</div>	<div>Approved</div> <div>PH</div>	<div>Date</div> <div>JUN 18</div>				
<div>Client</div> <div>EAST LINDSEY DC</div>		<div>AECOM Internal Project No.</div> <div>08251017</div>	<div>Suitability</div> <div>-</div>			<div>Drawing Number</div> <div>001</div>	<div>Rev</div> <div>-</div>			
		<div>Scale @ A3</div> <div>NTS</div>	<div>Zone / Mileage</div> <div>-</div>							

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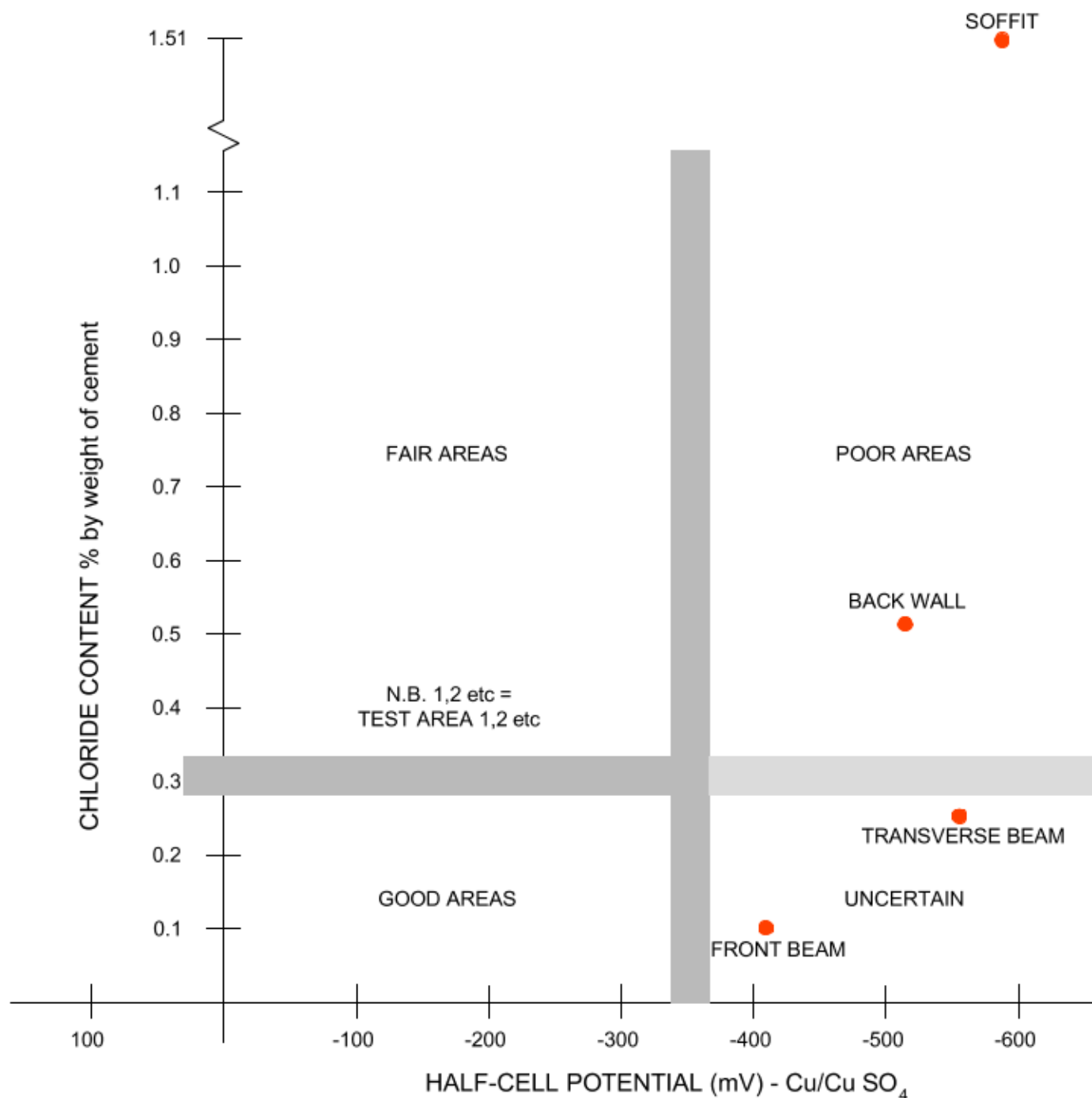
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☐ = Rust Staining

 = Exposed Reinforcement

LOCATION 3 - TRANSVERSE BEAM

LOCATION 4 - FRONT BEAM



NB: Chloride contents have been calculated assuming a cement content of 14%. Values shown for each test area are maximum negative half-cell potential and associated chloride content at reinforcement (corrosion potential readings taken less than 500mm above ground level are excluded)

Explanation of Good/Fair/Poor/Uncertain designations is included in "Interpretation of Results" section of this report.

SUMMARY OF MOST ONEROUS CORROSION POTENTIAL AND CHLORIDE ION TEST RESULTS

Based on Figure 1 in BD43
(Thresholds for impregnation and monitoring structures in service more than six years old)

FIGURE 3 - TEST AREA 1



TEST RESULTS

AECOM

1535

AECOM Office		CHESTERFIELD		Client	EAST LINDSEY DC
Structure Name		SUTTON-ON-SEA COLONNADE WALL			
Structure Number		SOS		Site Survey Ref	23/5/18/02
Date of Survey		23/05/18		Surveyed By	M EVANS
Weather Conditions		OVERCAST		Signature	
Condition of Test Surface		DRY			
Temperature (°C)		12	Temperature Coefficient Applied to Results		NO
Connection Type		SCREW		Pre-wetted	YES

	Location 1 - Soffit (SA)		Location 2 - Back Beam (SB)	
	Depth (mm)	%	Depth (mm)	%
Chloride ion content % by weight of concrete	0-27	0.049	0-28	0.085
	27-64	0.050	28-50	0.071
	64-84	0.036	50-75	0.071
Depth of Carbonation (mm)	8		9	
Reinforcement Cover (mm)	<14		19	
Resistivity (kΩ.cm) Minimum	16.3		11.9	
Note: Laboratory determination of chloride ion content is carried out by a separately accredited external organisation, not AECOM.				

SEE DRAWINGS 003 AND 004

	Location 3 - Transverse Beam (SC)		Location 4 - Front Beam (SD)	
	Depth (mm)	%	Depth (mm)	%
Chloride ion content % by weight of concrete	0-24	0.056	0-35	0.071
	24-48	0.071	35-54	0.028
	54-74	0.035	54-74	0.035
Depth of Carbonation (mm)	16		18	
Reinforcement Cover (mm)	<14		17	
Resistivity (kΩ.cm) Minimum	42.1		36.7	
Note: Laboratory determination of chloride ion content is carried out by a separately accredited external organisation, not AECOM.				

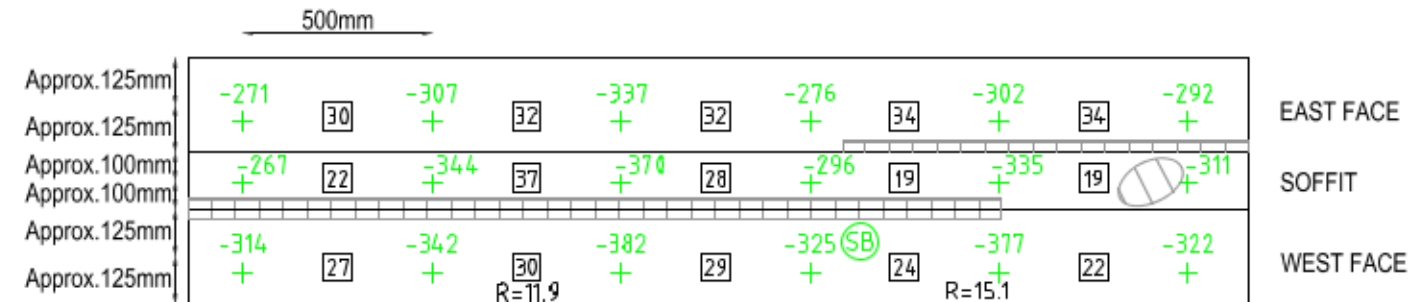
Structures Testing Manager's Signature	Test Area	TEST AREA 2	Around Column AA
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> -200 = Half Cell Reading (mV) R=4.3 = Resistivity (kΩ.cm) ⊕ = Corrosion Potential Connection ▨ = Leakage ▩ = Delamination ☐ = Rust Staining
(-123) = Half Cell Closing Reading (mV) 45 = Cover to Steel (mm) ⊗ = Dust Sample Location ▤ = Spalling ⊠ = Exposed Reinforcement

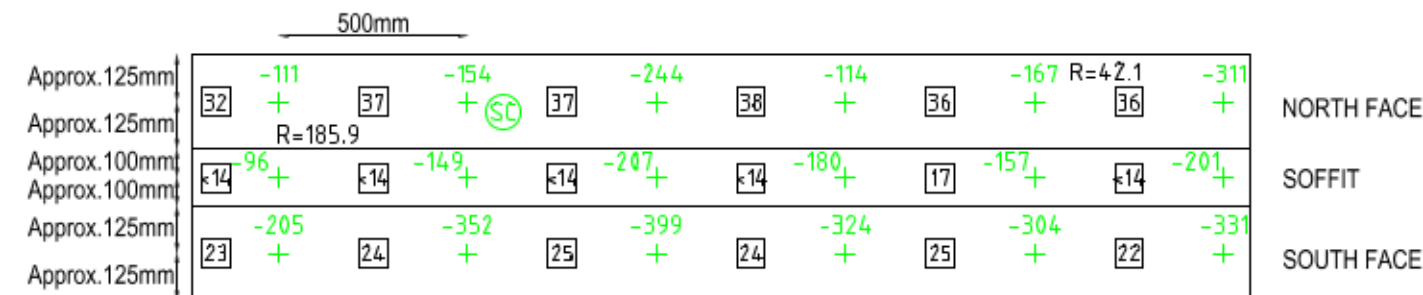


Location Sketch & Readings

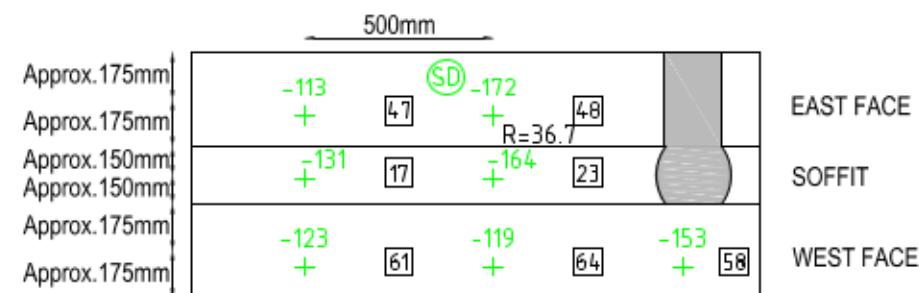
> -200 = Half Cell Reading (mV) R=4.3 = Resistivity (kΩ.cm) Ⓢ = Corrosion Potential Connection ☐ = Leakage ☐ = Delamination ☐ = Rust Staining
 (-123) = Half Cell Closing Reading (mV) 45 = Cover to Steel (mm) ⓈX = Dust Sample Location ☐ = Spalling ☐ = Exposed Reinforcement




LOCATION 2 - BEAM ABOVE STAIRWAY



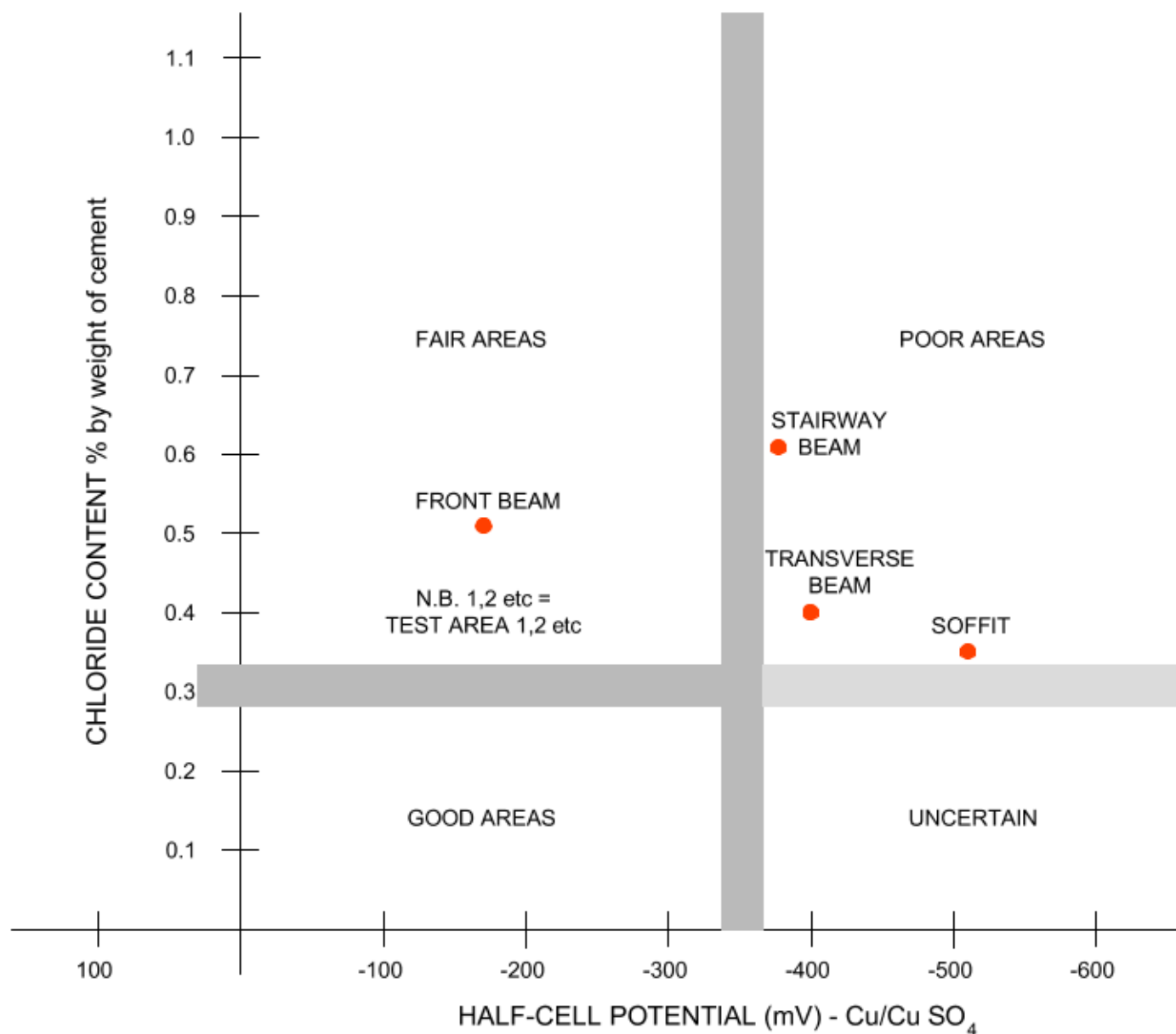
LOCATION 3 - TRANSVERSE BEAM



LOCATION 4 - FRONT BEAM

<div>Project Title</div> <div>SUTTON-ON-SEA COLONNADE WALL 2018</div>	<div>Drawing Title</div> <div>CONCRETE TEST RESULTS TEST AREA 2 AT COLUMN AA</div>	<div>Purpose of issue</div> <div>-</div>					<div>THIS DOCUMENT HAS BEEN PREPARED PURSUANT TO AND SUBJECT TO THE TERMS OF AECOM'S APPOINTMENT BY ITS CLIENT. AECOM ACCEPTS NO LIABILITY FOR ANY USE OF THIS DOCUMENT OTHER THAN BY ITS ORIGINAL CLIENT OR FOLLOWING AECOM'S EXPRESS AGREEMENT TO SUCH USE, AND ONLY FOR THE PURPOSES FOR WHICH IT WAS PREPARED AND PROVIDED.</div>		<div>AECOM Infrastructure & Environment UK Limited</div> <div>Royal Court, Basil Close Chesterfield S41 7SL Tel: +44 (0)1246 209 221 Fax: +44 (0)1246 209 229 www.aecom.com</div> <div></div>			
<div>Designed</div> <div>-</div>					<div>Drawn</div> <div>AS</div>	<div>Checked</div> <div>ME</div>					<div>Approved</div> <div>PH</div>	<div>Date</div> <div>JUN 18</div>
<div>AECOM Internal Project No.</div> <div>08251017</div>					<div>Suitability</div> <div>-</div>						<div>Drawing Number</div> <div>004</div>	<div>Rev</div> <div>-</div>
<div>Scale @ A3</div> <div>NTS</div>					<div>Zone / Mileage</div> <div>-</div>							
<div>Client</div> <div>EAST LINDSEY DC</div>												

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NB: Chloride contents have been calculated assuming a cement content of 14%. Values shown for each test area are maximum negative half-cell potential and associated chloride content at reinforcement (corrosion potential readings taken less than 500mm above ground level are excluded)

Explanation of Good/Fair/Poor/Uncertain designations is included in "Interpretation of Results" section of this report.

SUMMARY OF MOST ONEROUS CORROSION POTENTIAL AND CHLORIDE ION TEST RESULTS

Based on Figure 1 in BD43
(Thresholds for impregnation and monitoring structures in service more than six years old)

FIGURE 4 - TEST AREA 2



TEST RESULTS



1535

AECOM Office		CHESTERFIELD		Client	EAST LINDSEY DC
Structure Name		SUTTON-ON-SEA COLONNADE WALL			
Structure Number		SOS		Site Survey Ref	23/5/18/03
Date of Survey		23/05/18		Surveyed By	M EVANS
Weather Conditions		OVERCAST		Signature	<i>[Signature]</i>
Condition of Test Surface		DRY			
Temperature (°C)		12	Temperature Coefficient Applied to Results		NO
Connection Type		SCREW		Pre-wetted	YES

	Location 1 - Back Wall (SA)		Location 2 - Soffit (SB)	
	Depth (mm)	%	Depth (mm)	%
Chloride ion content % by weight of concrete	0-33	0.028	0-30	0.071
	33-48	0.099	30-58	0.113
	48-83	0.099	58-81	0.147
Depth of Carbonation (mm)	+28		10	
Reinforcement Cover (mm)	92		<14	
Resistivity (kΩ.cm) Minimum	9.8		16.2	

Note: Laboratory determination of chloride ion content is carried out by a separately accredited external organisation, not AECOM.

SEE DRAWINGS 005 AND 006

	Location 3 - Transverse Beam (SD)		Location 4 - Front Beam (SE)	
	Depth (mm)	%	Depth (mm)	%
Chloride ion content % by weight of concrete	0-40	0.283	0-23	0.035
	40-57	0.106	23-48	0.021
	57-85	0.141	48-79	0.028
Depth of Carbonation (mm)	+35		+34	
Reinforcement Cover (mm)	<14		23	
Resistivity (kΩ.cm) Minimum	1.9		128.6	

Note: Laboratory determination of chloride ion content is carried out by a separately accredited external organisation, not AECOM.

Structures Testing Manager's Signature	Test Area	TEST AREA 3	Around Column BB
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Location Sketch & Readings

> -200 = Half Cell Reading (mV)
(-123) = Half Cell Closing Reading (mV)

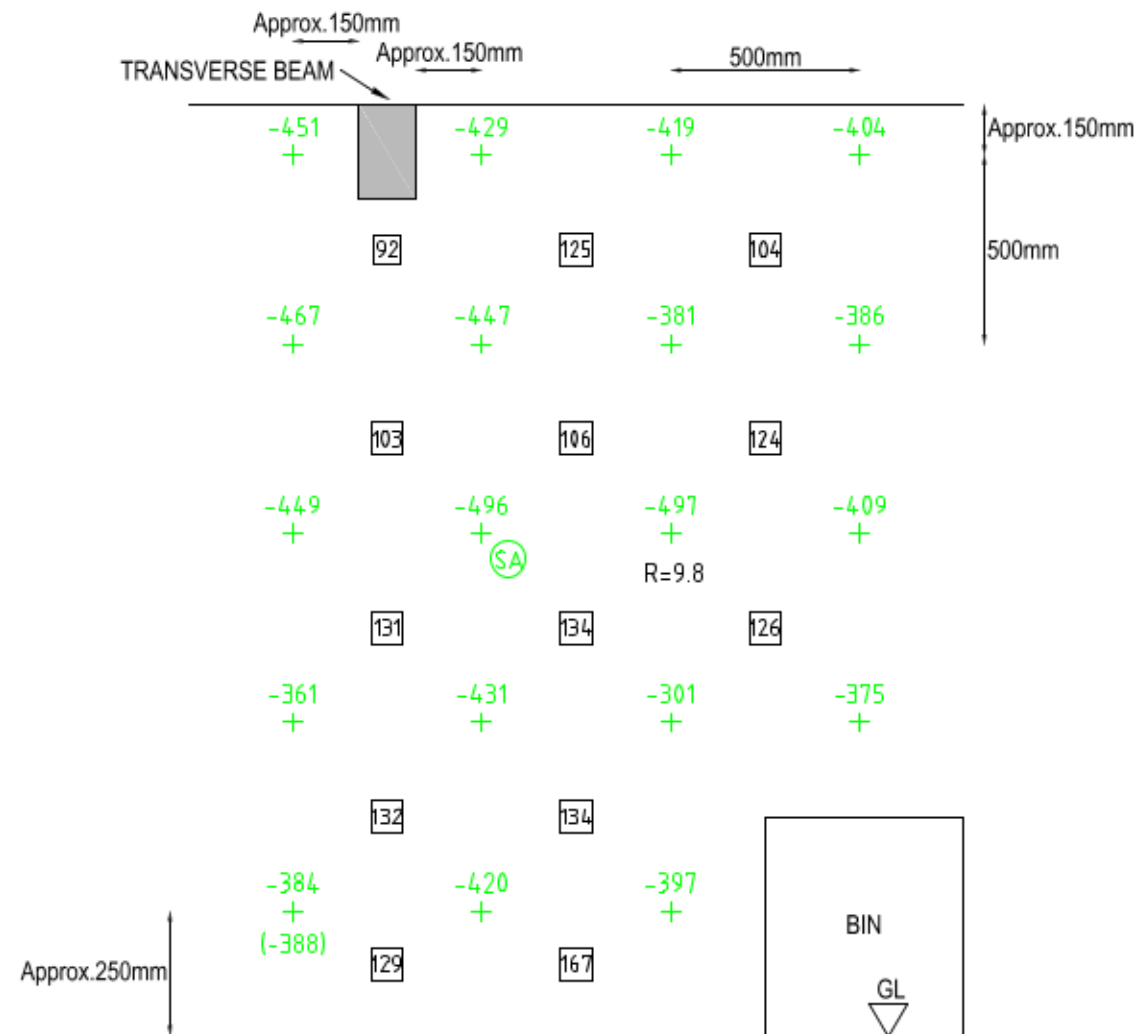
R=4.3 = Resistivity (kΩ.cm)
45 = Cover to Steel (mm)

⊕ = Corrosion Potential Connection
⊗ = Dust Sample Location

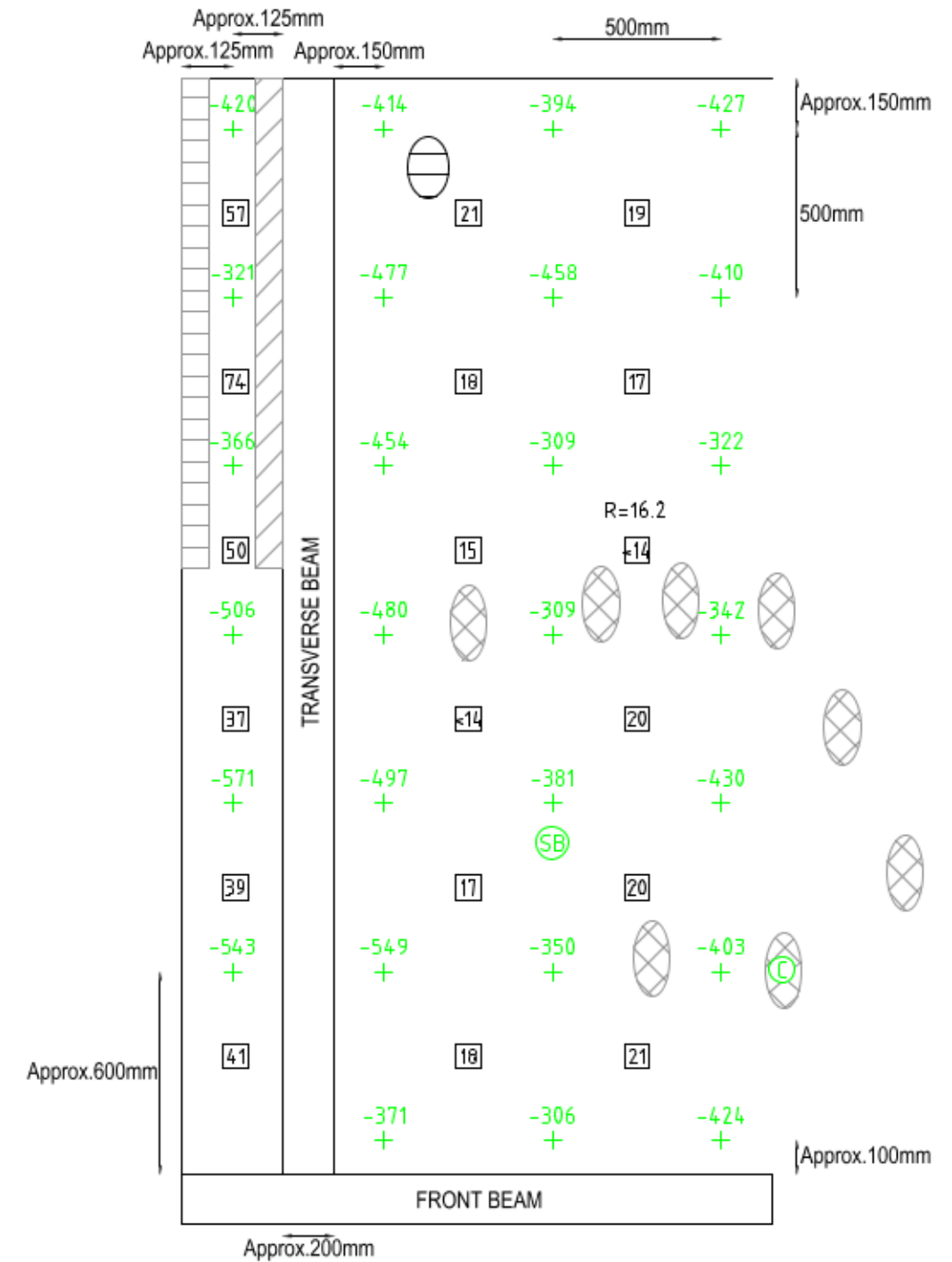
⊞ = Leakage
⊞ = Spalling

⊞ = Delamination
⊞ = Exposed Reinforcement

⊞ = Rust Staining



LOCATION 1 - BACK WALL



LOCATION 2 - SOFFIT

Project Title
SUTTON-ON-SEA COLONNADE WALL
2018

Client
EAST LINDSEY DC

Drawing Title
CONCRETE TEST RESULTS
TEST AREA 3
AT COLUMN BB

Purpose of issue
-

Designed -	Drawn AS	Checked ME	Approved PH	Date JUN 18
AECOM Internal Project No. 08251017		Suitability -		
Scale @ A3 NTS		Zone / Mileage -		

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005

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Royal Court, Basil Close
Chesterfield
S41 7SL
Tel: +44 (0)1246 209 221
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Location Sketch & Readings

> -200 = Half Cell Reading (mV)

(-123) = Half Cell Closing Reading (mV)

R=4.3 = Resistivity (kΩ.cm)

45 = Cover to Steel (mm)

⊕ = Corrosion Potential Connection

⊗ = Dust Sample Location

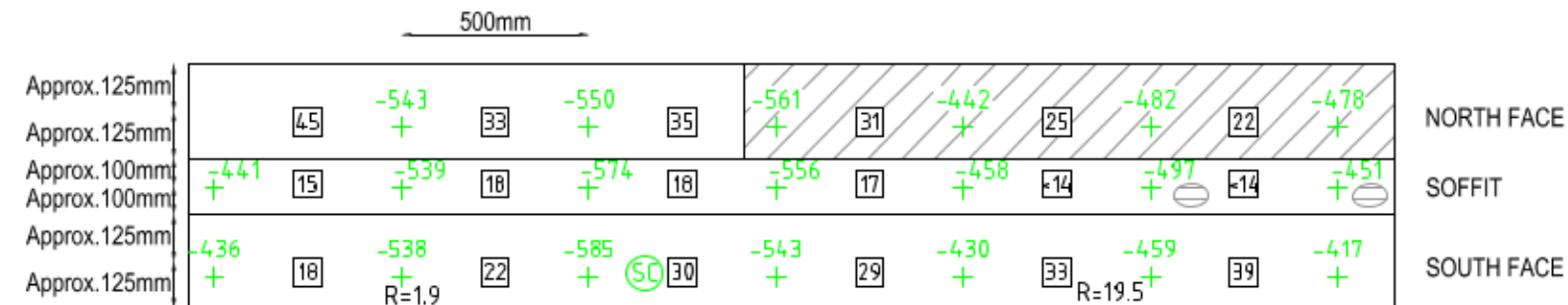
⊞ = Leakage

⊞ = Spalling

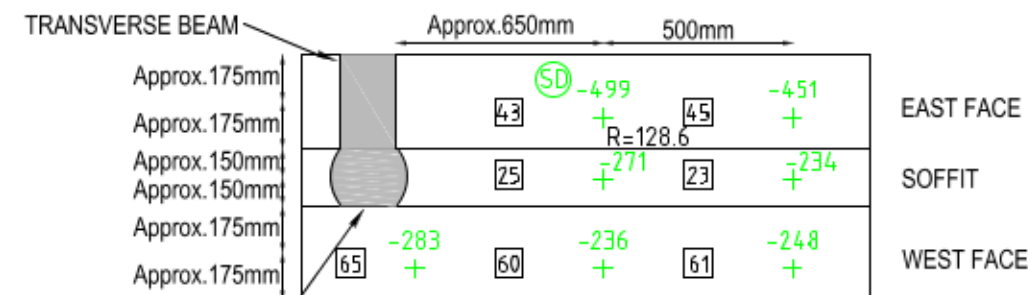
⊞ = Delamination

⊞ = Exposed Reinforcement

⊞ = Rust Staining



LOCATION 3 - TRANSVERSE BEAM



LOCATION 4 - FRONT BEAM

Project Title
SUTTON-ON-SEA COLONNADE WALL
2018

Client
EAST LINDSEY DC

Drawing Title
CONCRETE TEST RESULTS
TEST AREA 3
AT COLUMN BB

Purpose of issue

-

Designed
-

Drawn
AS

Checked
ME

Approved
PH

Date
JUN 18

AECOM Internal Project No.
08251017

Suitability
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Scale @ A3
NTS

Zone / Mileage
-

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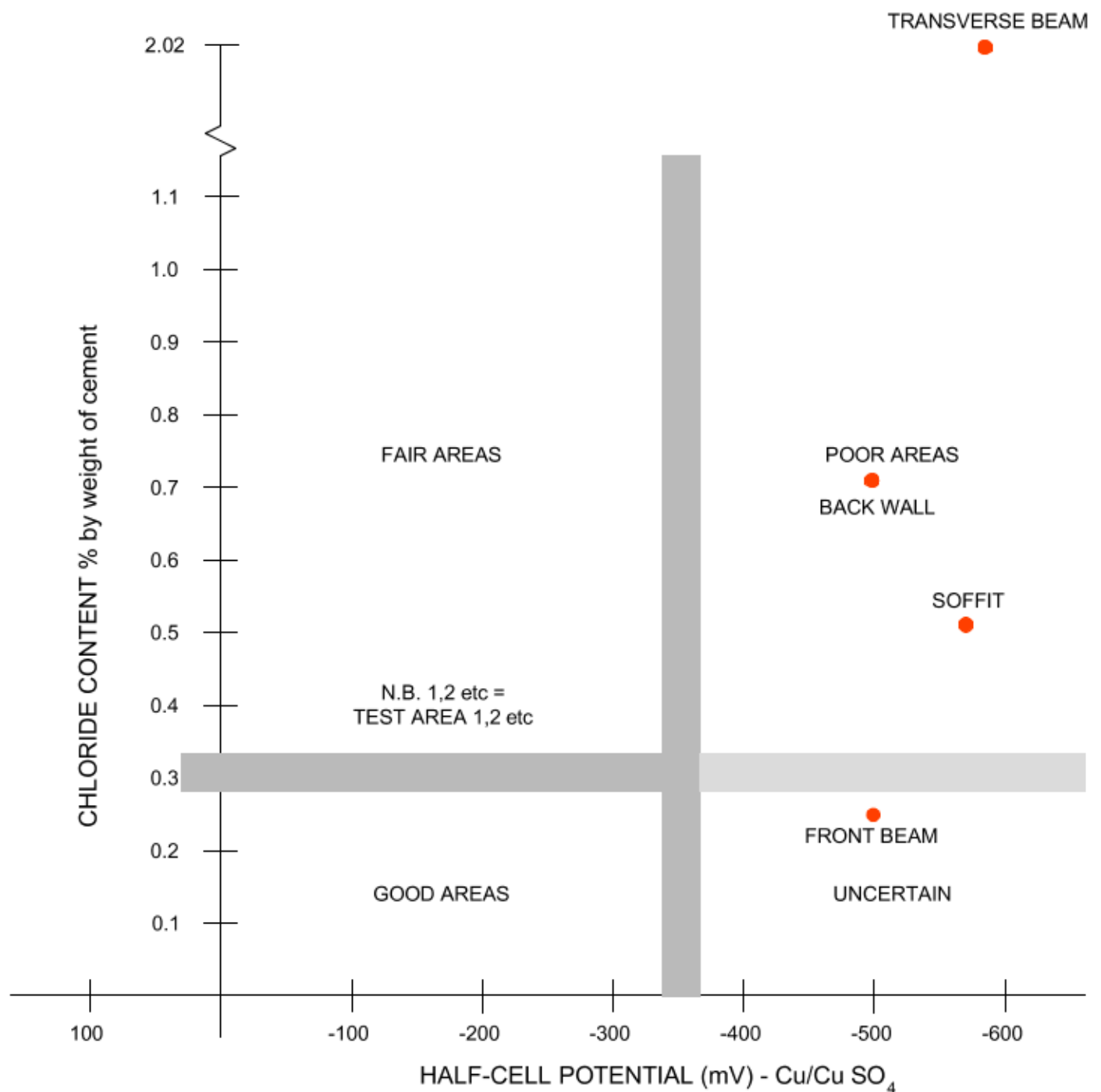
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AECOM Infrastructure & Environment UK Limited

Royal Court, Basil Close
Chesterfield
S41 7SL
Tel: +44 (0)1246 209 221
Fax: +44 (0)1246 209 229
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NB: Chloride contents have been calculated assuming a cement content of 14%. Values shown for each test area are maximum negative half-cell potential and associated chloride content at reinforcement (corrosion potential readings taken less than 500mm above ground level are excluded)

Explanation of Good/Fair/Poor/Uncertain designations is included in "Interpretation of Results" section of this report.

SUMMARY OF MOST ONEROUS CORROSION POTENTIAL AND CHLORIDE ION TEST RESULTS

Based on Figure 1 in BD43
(Thresholds for impregnation and monitoring structures in service more than six years old)

FIGURE 5 - TEST AREA 3



TEST RESULTS

AECOM

1535

AECOM Office		CHESTERFIELD		Client	EAST LINDSEY DC
Structure Name		SUTTON-ON-SEA COLONNADE WALL			
Structure Number		SOS		Site Survey Ref	24/5/18/01
Date of Survey		24/05/18		Surveyed By	M EVANS
Weather Conditions		OVERCAST		Signature	<i>M. Evans</i>
Condition of Test Surface		DRY			
Temperature (°C)		13	Temperature Coefficient Applied to Results		NO
Connection Type		SCREW		Pre-wetted	YES

	Location 1 - Back Wall (SA)		Location 2 - Soffit (SB)	
	Depth (mm)	%	Depth (mm)	%
Chloride ion content % by weight of concrete	0-25	<0.003	0-38	0.248
	25-47	<0.003	38-54	0.277
	47-72	<0.003	54-74	0.232
Depth of Carbonation (mm)	17		18	
Reinforcement Cover (mm)	86		<14	
Resistivity (kΩ.cm) Minimum	19.2		17.9	

Note: Laboratory determination of chloride ion content is carried out by a separately accredited external organisation, not AECOM.

SEE DRAWINGS 007 AND 008

	Location 3 - Transverse Beam (SC)		Location 4 - Front Beam (SD)	
	Depth (mm)	%	Depth (mm)	%
Chloride ion content % by weight of concrete	0-23	0.071	0-23	0.021
	23-46	0.035	23-50	0.021
	46-75	0.014	50-74	0.021
Depth of Carbonation (mm)	22		26	
Reinforcement Cover (mm)	<14		20	
Resistivity (kΩ.cm) Minimum	128.6		105.0	

Note: Laboratory determination of chloride ion content is carried out by a separately accredited external organisation, not AECOM.

Structures Testing Manager's Signature	Test Area	TEST AREA 4	Around Column U
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Location Sketch & Readings

> -200 = Half Cell Reading (mV)
(-123) = Half Cell Closing Reading (mV)

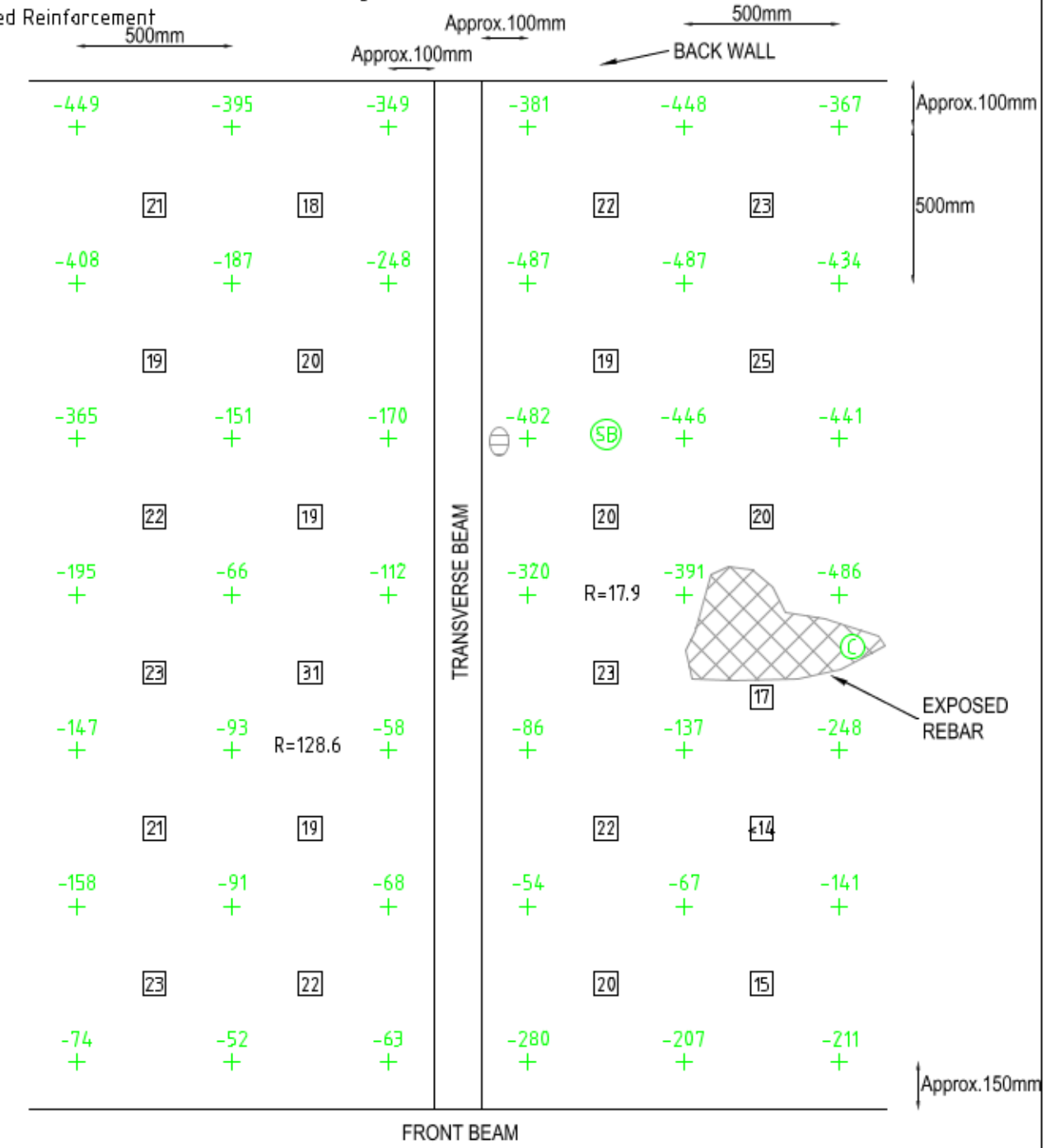
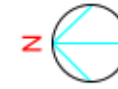
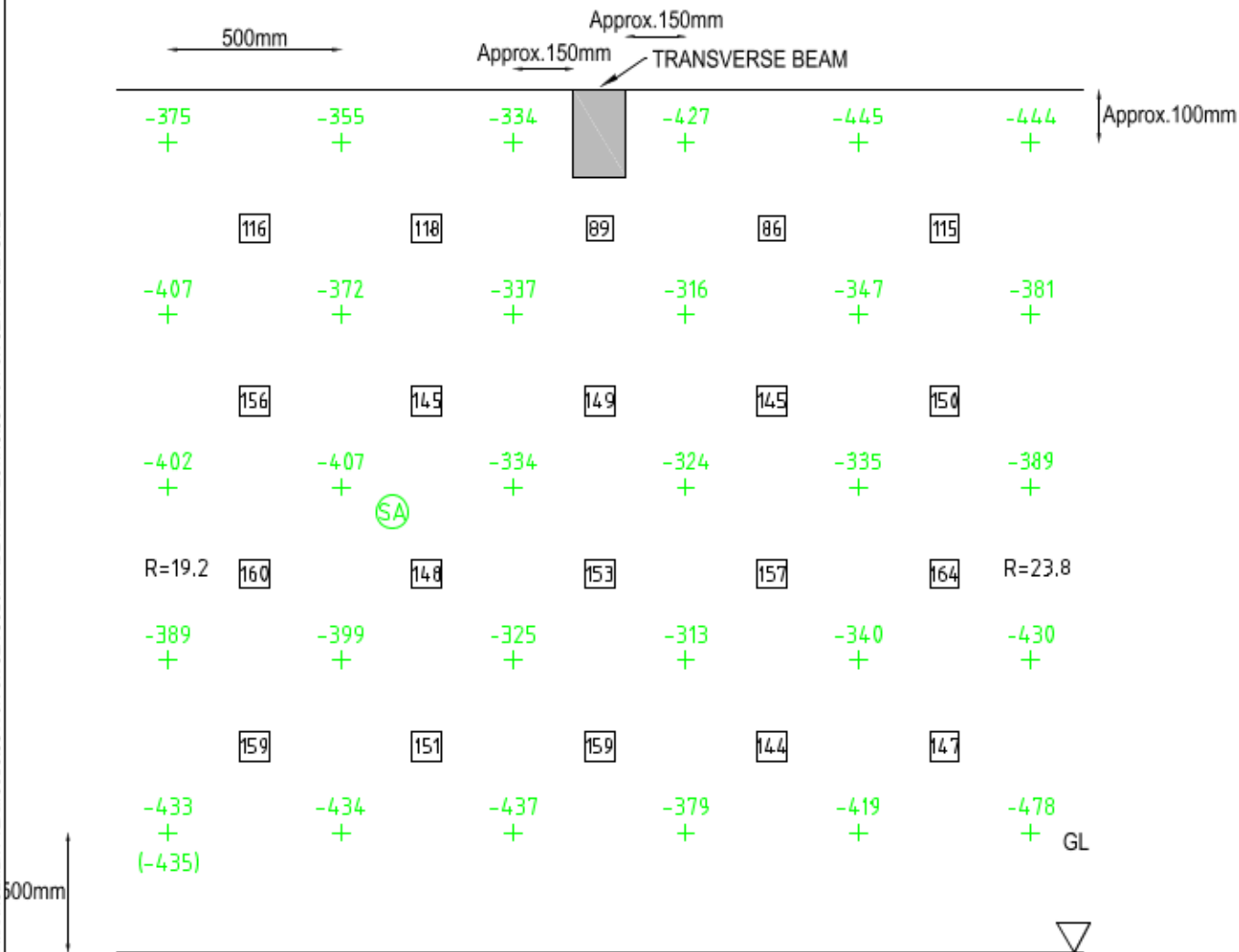
R=4.3 = Resistivity (kΩ.cm)
45 = Cover to Steel (mm)

⊕ = Corrosion Potential Connection
⊗ = Dust Sample Location

⊞ = Leakage
⊞ = Spalling

⊞ = Delamination
⊞ = Exposed Reinforcement

⊞ = Rust Staining



<p>Project Title</p> <p>SUTTON-ON-SEA COLONNADE WALL 2018</p> <p>Client</p> <p>EAST LINDSEY DC</p>	<p>Drawing Title</p> <p>CONCRETE TEST RESULTS</p> <p>TEST AREA 4</p> <p>AT COLUMN U</p>	<p>Purpose of issue</p> <p>-</p> <table border="1"> <tr> <td>Designed</td><td>Drawn</td><td>Checked</td><td>Approved</td><td>Date</td></tr> <tr> <td>-</td><td>AS</td><td>ME</td><td>PH</td><td>JUN 18</td></tr> </table> <p>AECOM Internal Project No.</p> <p>08251017</p> <p>Scale @ A3</p> <p>NTS</p> <p>Suitability</p> <p>-</p> <p>Zone / Mileage</p> <p>-</p>	Designed	Drawn	Checked	Approved	Date	-	AS	ME	PH	JUN 18	<p>THIS DOCUMENT HAS BEEN PREPARED PURSUANT TO AND SUBJECT TO THE TERMS OF AECOM'S APPOINTMENT BY ITS CLIENT. AECOM ACCEPTS NO LIABILITY FOR ANY USE OF THIS DOCUMENT OTHER THAN BY ITS ORIGINAL CLIENT OR FOLLOWING AECOM'S EXPRESS AGREEMENT TO SUCH USE, AND ONLY FOR THE PURPOSES FOR WHICH IT WAS PREPARED AND PROVIDED.</p> <p>Drawing Number</p> <p>007</p> <p>Rev</p> <p>-</p>	<p>AECOM Infrastructure & Environment UK Limited</p> <p>Royal Court, Basil Close</p> <p>Chesterfield</p> <p>S41 7SL</p> <p>Tel: +44 (0)1246 209 221</p> <p>Fax: +44 (0)1246 209 229</p> <p>www.aecom.com</p> <p>AECOM</p>
Designed	Drawn	Checked	Approved	Date										
-	AS	ME	PH	JUN 18										

Location Sketch & Readings

> -200 = Half Cell Reading (mV)

(-123) = Half Cell Closing Reading (mV)

R=4.3 = Resistivity (kΩ.cm)

45 = Cover to Steel (mm)

⊕ = Corrosion Potential Connection

⊗ = Dust Sample Location

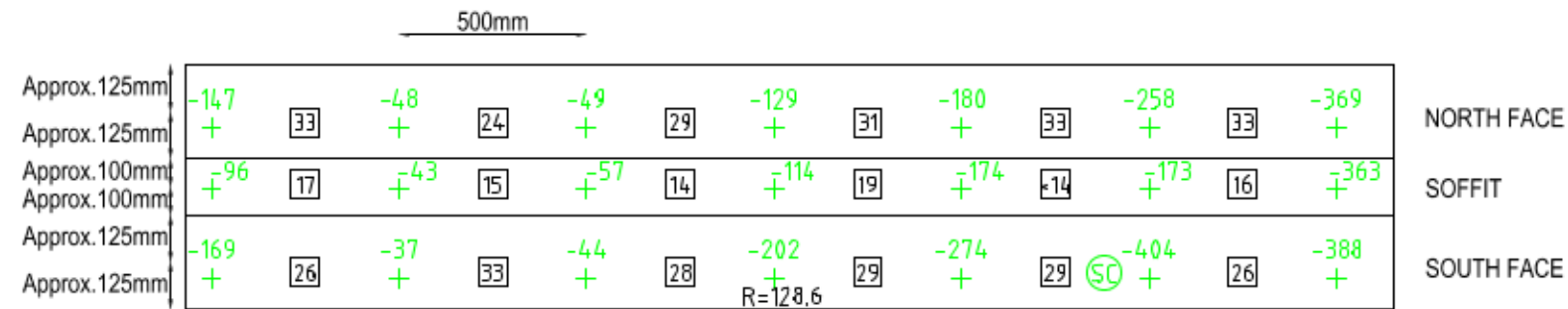
⊞ = Leakage

⊞ = Spalling

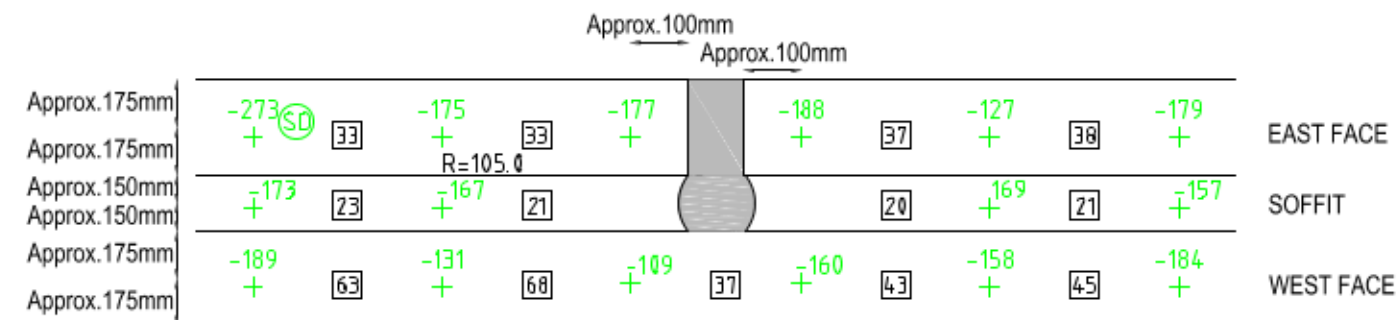
⊞ = Delamination

⊞ = Exposed Reinforcement

⊞ = Rust Staining



LOCATION 3 - TRANSVERSE BEAM



LOCATION 4 - FRONT BEAM

Project Title
SUTTON-ON-SEA COLONNADE WALL
2018

Client
EAST LINDSEY DC

Drawing Title
CONCRETE TEST RESULTS
TEST AREA 4
AT COLUMN U

Purpose of issue
-

Designed -	Drawn AS	Checked ME	Approved PH	Date JUN 18
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AECOM Internal Project No.
08251017

Scale @ A3
NTS

Suitability
-

Zone / Mileage
-

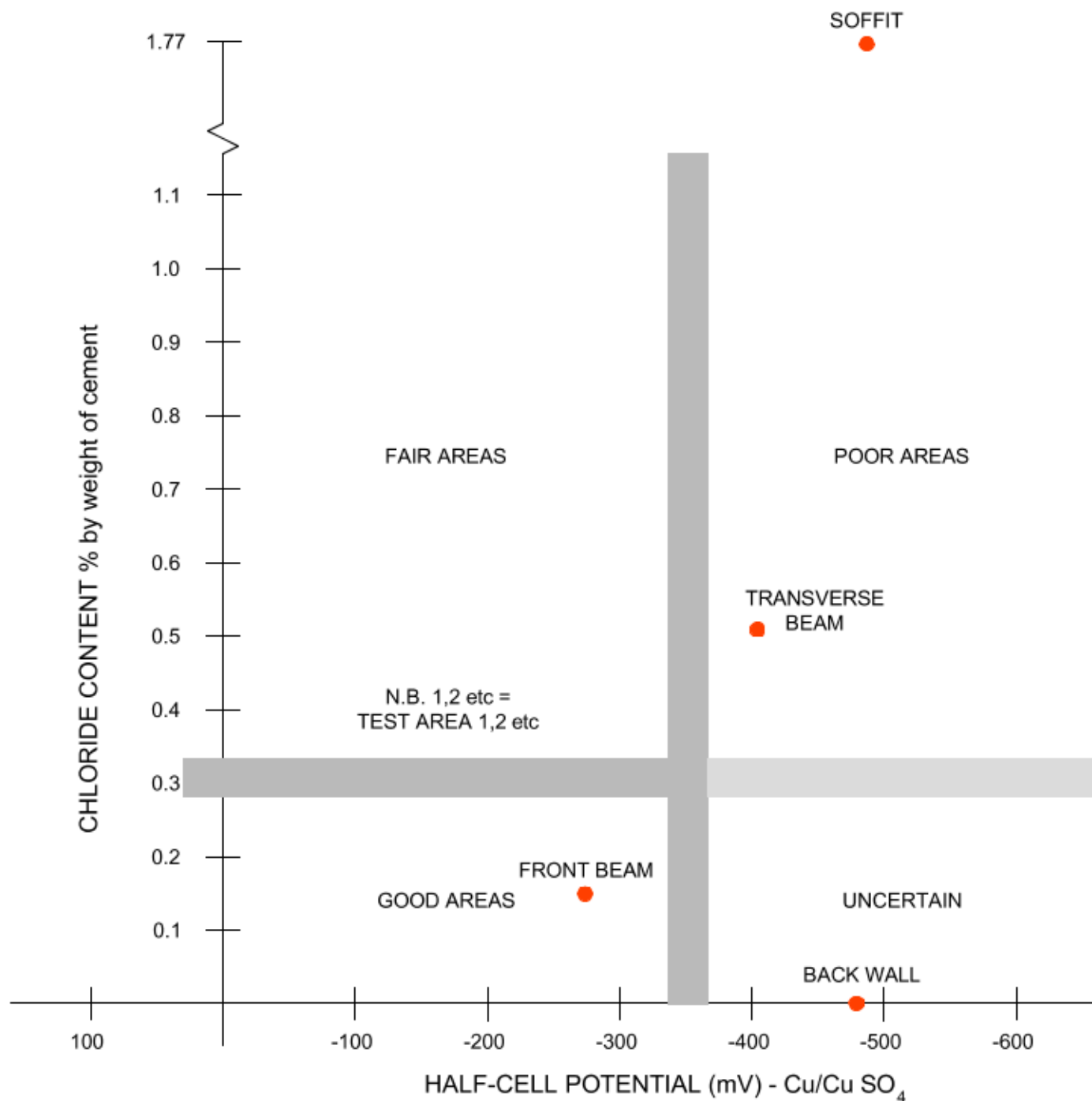
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Royal Court, Basil Close
Chesterfield
S41 7SL
Tel: +44 (0)1246 209 221
Fax: +44 (0)1246 209 229
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NB: Chloride contents have been calculated assuming a cement content of 14%. Values shown for each test area are maximum negative half-cell potential and associated chloride content at reinforcement (corrosion potential readings taken less than 500mm above ground level are excluded)

Explanation of Good/Fair/Poor/Uncertain designations is included in "Interpretation of Results" section of this report.

SUMMARY OF MOST ONEROUS CORROSION POTENTIAL AND CHLORIDE ION TEST RESULTS

Based on Figure 1 in BD43
(Thresholds for impregnation and monitoring structures in service more than six years old)

FIGURE 6 - TEST AREA 4



TEST RESULTS

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AECOM Office		CHESTERFIELD		Client	EAST LINDSEY DC
Structure Name		SUTTON-ON-SEA COLONNADE WALL			
Structure Number		SOS		Site Survey Ref	24/5/18/05
Date of Survey		24/05/18		Surveyed By	M EVANS
Weather Conditions		OVERCAST		Signature	
Condition of Test Surface		DRY			
Temperature (°C)		16	Temperature Coefficient Applied to Results		NO
Connection Type		SCREW		Pre-wetted	YES

	Location 1 - Back Wall (S _A)		Location 2 - Soffit (S _B)	
	Depth (mm)	%	Depth (mm)	%
Chloride ion content % by weight of concrete	0-25	0.021	0-25	0.170
	25-49	0.007	25-49	0.177
	49-78	<0.003	49-85	0.142
Depth of Carbonation (mm)	10		5	
Reinforcement Cover (mm)	27		<14	
Resistivity (kΩ.cm) Minimum	10.8		12.6	
Note: Laboratory determination of chloride ion content is carried out by a separately accredited external organisation, not AECOM.				

SEE DRAWINGS 009 AND 010

	Location 3 - Front Beam (S _D)		Location 4 - Column K (S _D)	
	Depth (mm)	%	Depth (mm)	%
Chloride ion content % by weight of concrete	0-29	0.142	0-29	0.071
	29-51	0.121	29-49	0.085
	51-78	0.092	49-75	0.071
Depth of Carbonation (mm)	6		10	
Reinforcement Cover (mm)	16		26	
Resistivity (kΩ.cm) Minimum	4.5		85.2	
Note: Laboratory determination of chloride ion content is carried out by a separately accredited external organisation, not AECOM.				

Structures Testing Manager's Signature	Test Area	TEST AREA 5	Around Column K
--	-----------	-------------	-----------------

Location Sketch & Readings

> -200 = Half Cell Reading (mV)
(-123) = Half Cell Closing Reading (mV)

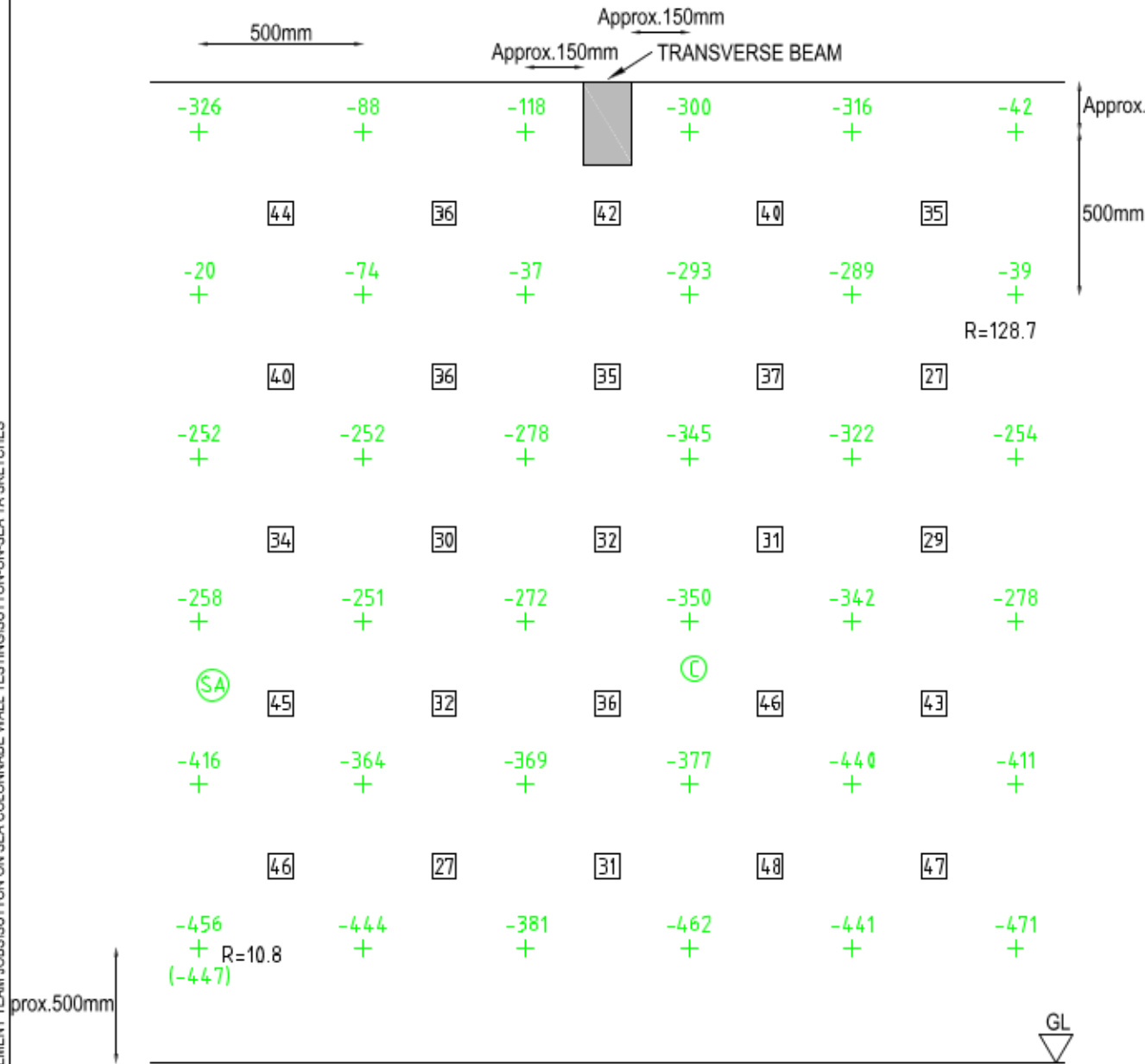
R=4.3 = Resistivity (kΩ.cm)
45 = Cover to Steel (mm)

⊕ = Corrosion Potential Connection
⊗ = Dust Sample Location

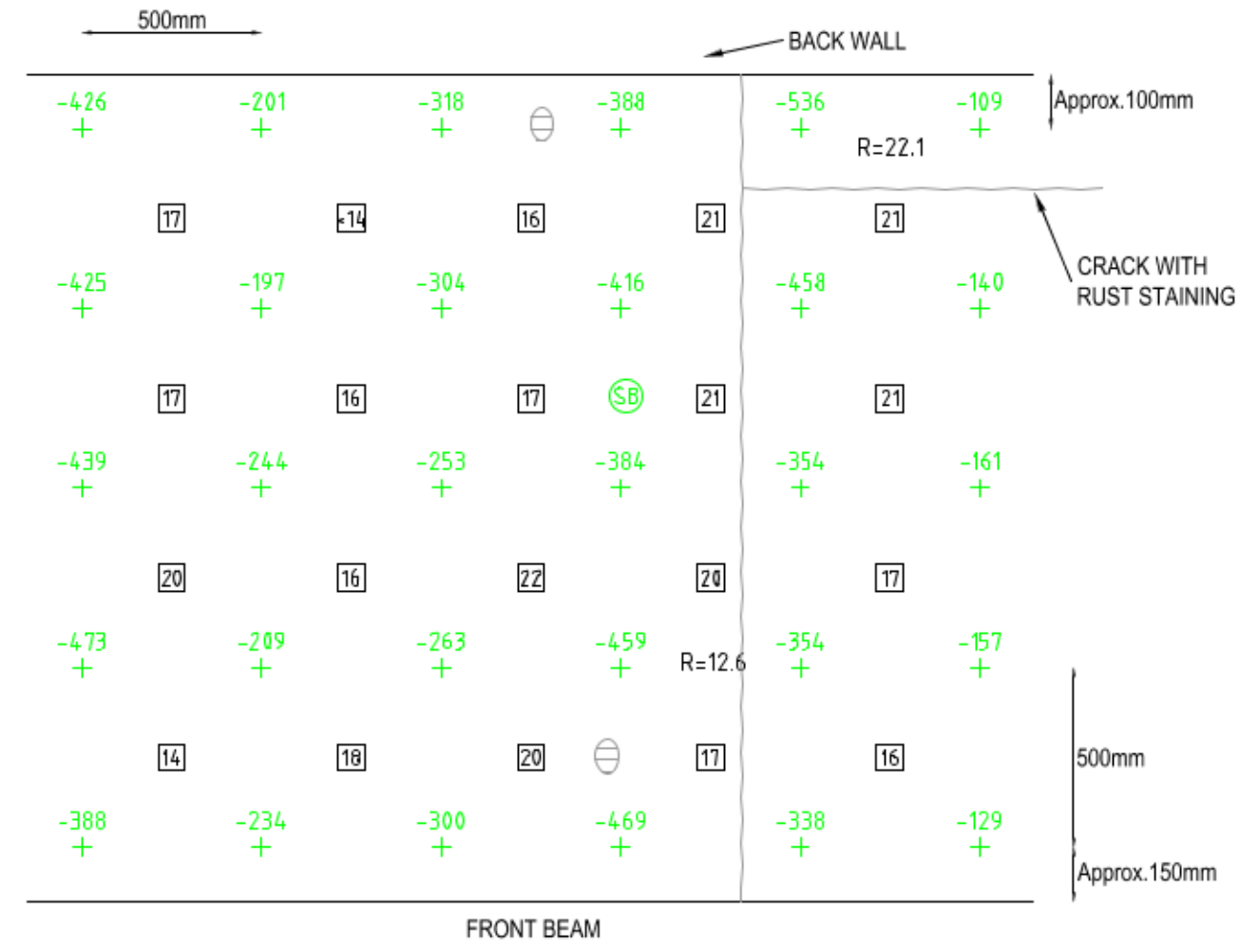
☐ = Leakage
☐ = Spalling

☐ = Delamination
☐ = Exposed Reinforcement

☐ = Rust Staining



LOCATION 1 - BACK WALL



LOCATION 2 - SOFFIT

Project Title
SUTTON-ON-SEA COLONNADE WALL
2018

Client
EAST LINDSEY DC

Drawing Title
CONCRETE TEST RESULTS
TEST AREA 5
AT COLUMN K

Purpose of issue
-

Designed -	Drawn AS	Checked ME	Approved PH	Date JUN 18
AECOM Internal Project No. 08251017			Suitability -	
Scale @ A3 NTS			Zone / Mileage -	

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Drawing Number
009

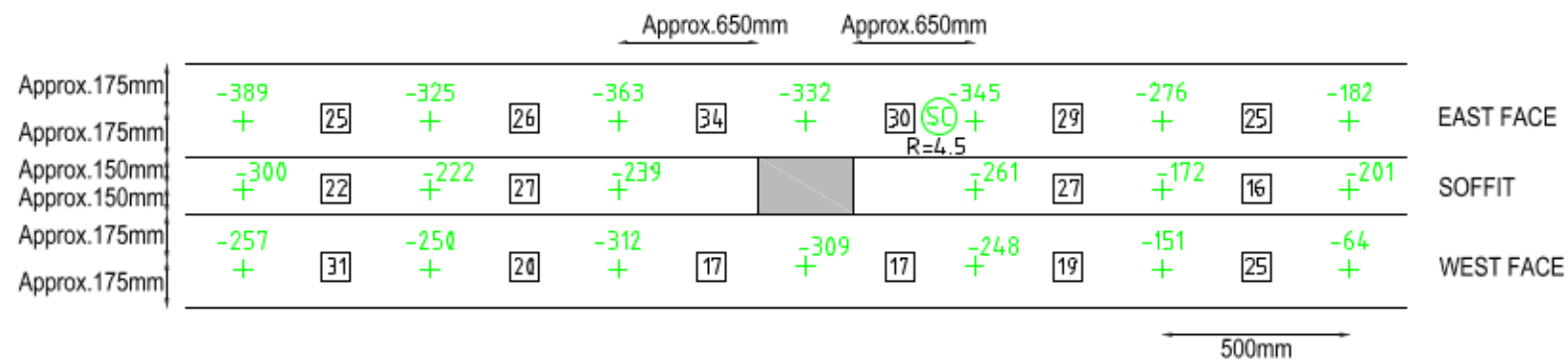
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-

AECOM Infrastructure & Environment UK Limited
Royal Court, Basil Close
Chesterfield
S41 7SL
Tel: +44 (0)1246 209 221
Fax: +44 (0)1246 209 229
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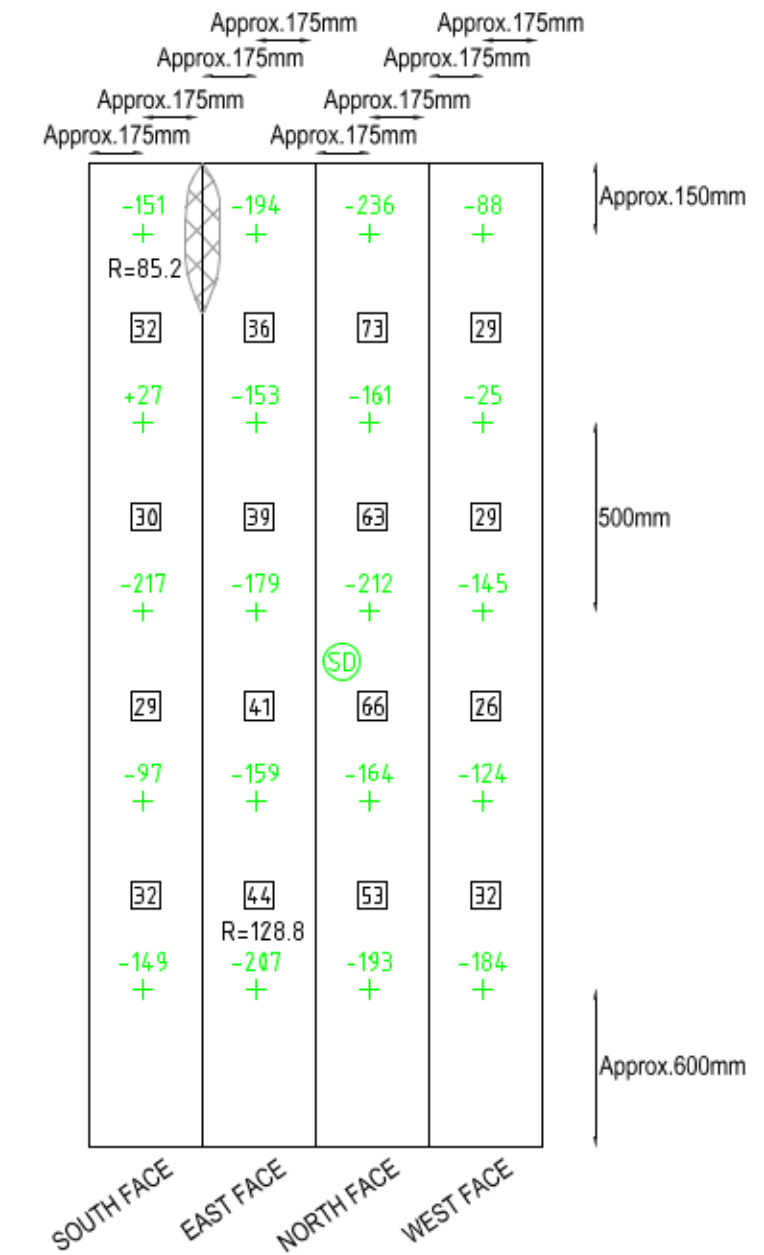
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Location Sketch & Readings

> -200 = Half Cell Reading (mV) R=4.3 = Resistivity (kΩ.cm) Ⓢ = Corrosion Potential Connection ☒ = Leakage ☒ = Delamination ☒ = Rust Staining
 (-123) = Half Cell Closing Reading (mV) 45 = Cover to Steel (mm) ⓈX = Dust Sample Location ☒ = Spalling ☒ = Exposed Reinforcement



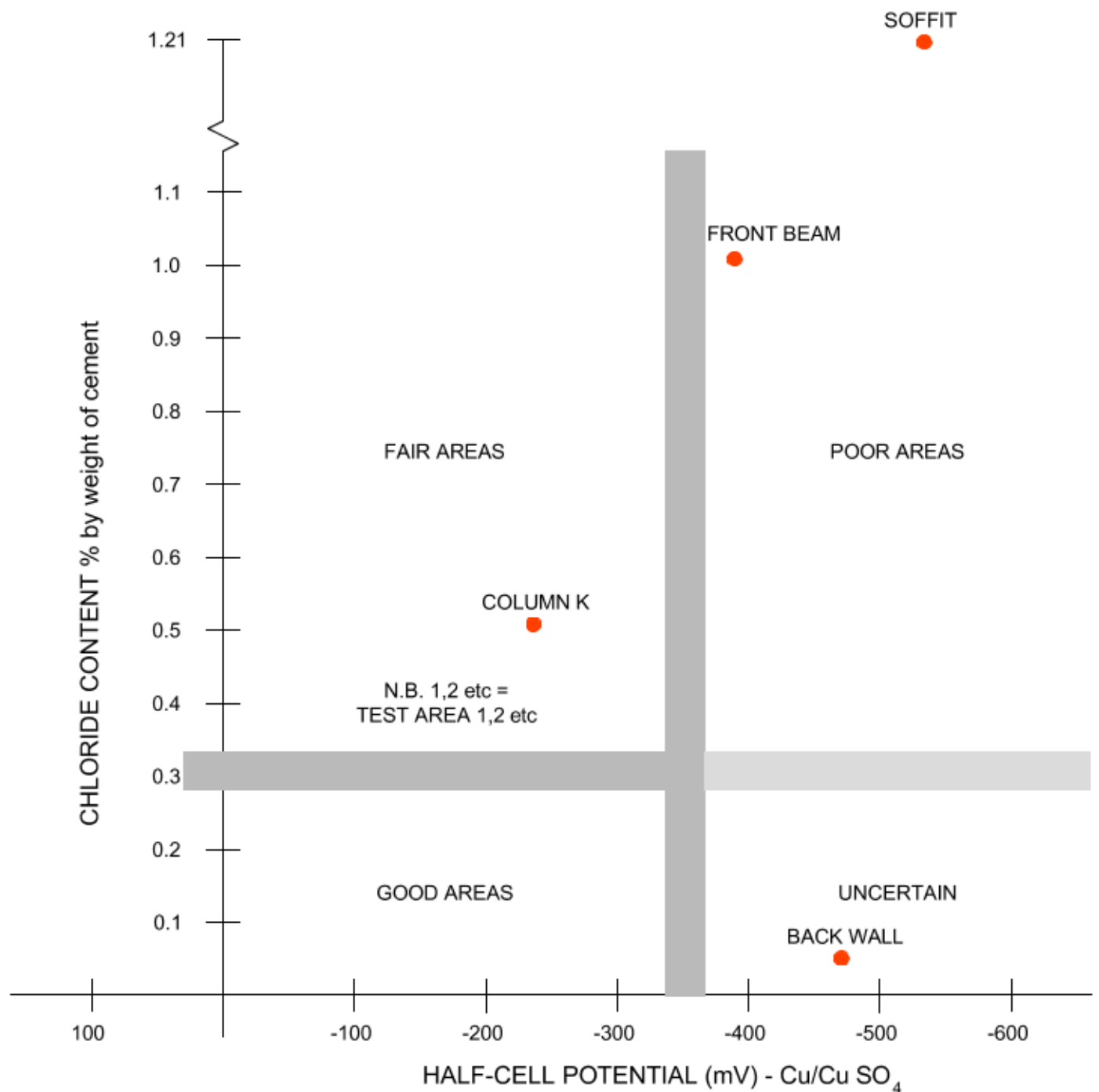
LOCATION 3 - FRONT BEAM



LOCATION 4 - COLUMN K

Project Title SUTTON-ON-SEA COLONNADE WALL 2018	Drawing Title CONCRETE TEST RESULTS TEST AREA 5 AT COLUMN K	Purpose of issue -					THIS DOCUMENT HAS BEEN PREPARED PURSUANT TO AND SUBJECT TO THE TERMS OF AECOM'S APPOINTMENT BY ITS CLIENT. AECOM ACCEPTS NO LIABILITY FOR ANY USE OF THIS DOCUMENT OTHER THAN BY ITS ORIGINAL CLIENT OR FOLLOWING AECOM'S EXPRESS AGREEMENT TO SUCH USE, AND ONLY FOR THE PURPOSES FOR WHICH IT WAS PREPARED AND PROVIDED.		AECOM Infrastructure & Environment UK Limited Royal Court, Basil Close Chesterfield S41 7SL Tel: +44 (0)1246 209 221 Fax: +44 (0)1246 209 229 www.aecom.com	
Client EAST LINDSEY DC		Designed -	Drawn AS	Checked ME	Approved PH	Date JUN 18				
		AECOM Internal Project No. 08251017			Suitability -		Drawing Number 010		Rev -	
		Scale @ A3 NTS			Zone / Mileage -					

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NB: Chloride contents have been calculated assuming a cement content of 14%. Values shown for each test area are maximum negative half-cell potential and associated chloride content at reinforcement (corrosion potential readings taken less than 500mm above ground level are excluded)

Explanation of Good/Fair/Poor/Uncertain designations is included in "Interpretation of Results" section of this report.

SUMMARY OF MOST ONEROUS CORROSION POTENTIAL AND CHLORIDE ION TEST RESULTS

Based on Figure 1 in BD43
(Thresholds for impregnation and monitoring structures in service more than six years old)

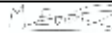
FIGURE 7 - TEST AREA 5



TEST RESULTS

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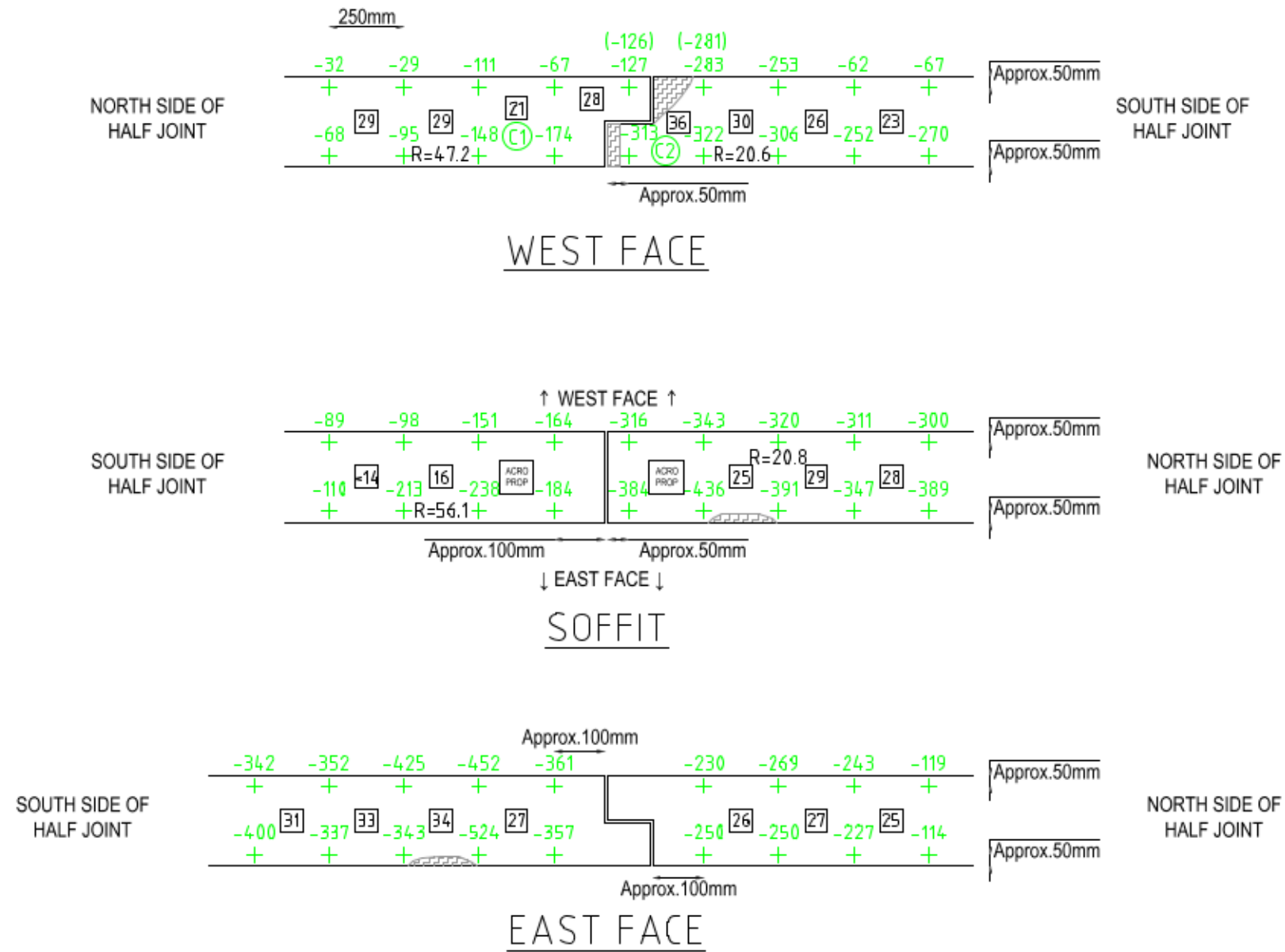
AECOM Office	CHESTERFIELD	Client	EAST LINDSEY DC
Structure Name	SUTTON-ON-SEA COLONNADE WALL		
Structure Number	SOS	Site Survey Ref	24/5/18/09
Date of Survey	24/05/18	Surveyed By	M EVANS
Weather Conditions	OVERCAST	Signature	
Condition of Test Surface	DRY		
Temperature (°C)	15	Temperature Coefficient Applied to Results	NO
Connection Type	SCREW	Pre-wetted	YES

SEE DRAWING 011

		NORTH SIDE OF HALF JOINT (C1)		SOUTH SIDE OF HALF JOINT (C2)	
Chloride ion content % by weight of concrete		Depth (mm)	%	Depth (mm)	%
		0-24	0.014	0-22	0.071
				22-34	0.071
Depth of Carbonation (mm)		4		18	
Reinforcement Cover (mm)		21		<14	
Resistivity (kΩ.cm) Minimum		47.2		20.8	
Note: Laboratory determination of chloride ion content is carried out by a separately accredited external organisation, not AECOM.					
Structures Testing Manager's Signature			Test Area	TEST AREA 6	
				Half Joint	

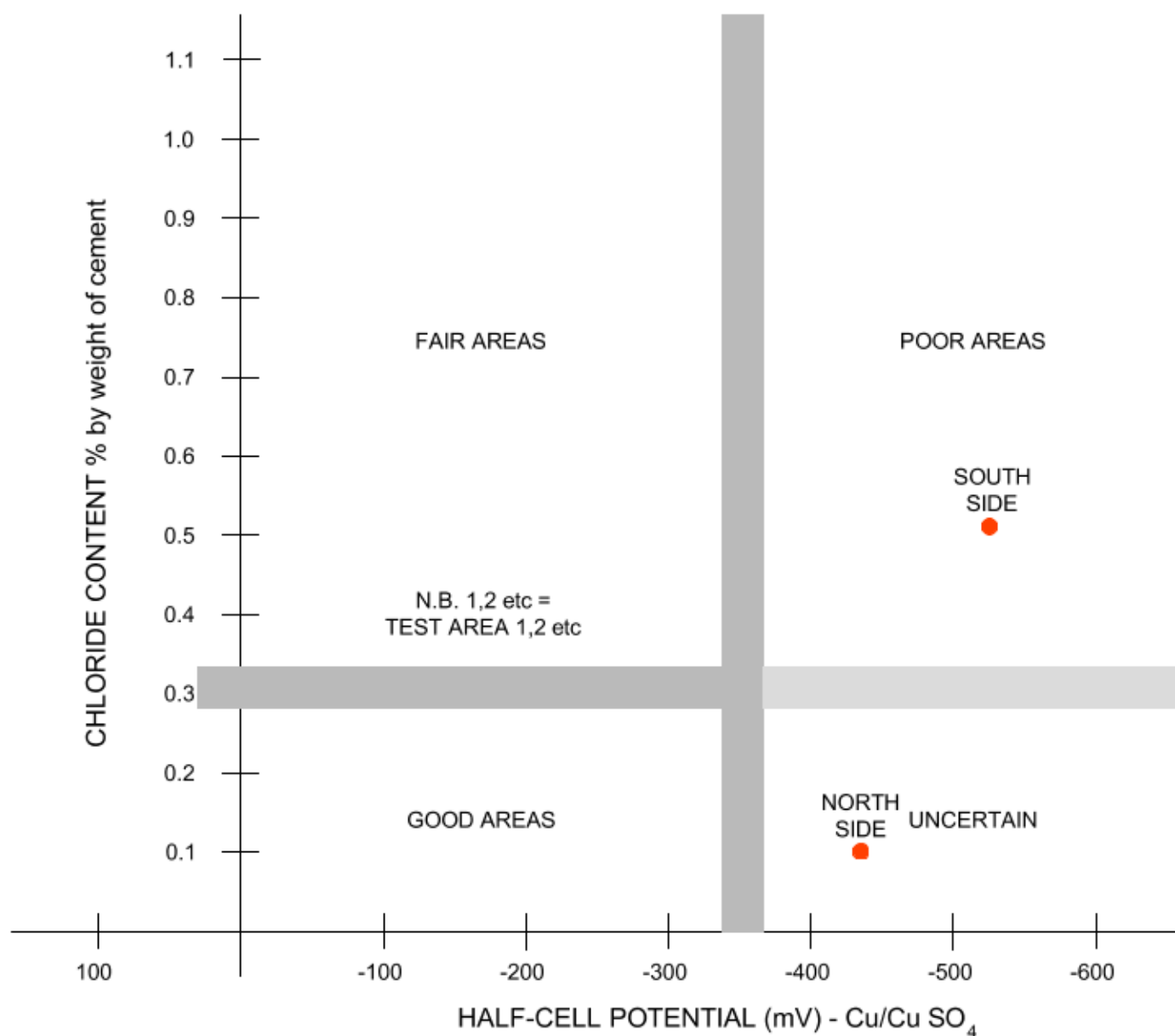
Location Sketch & Readings

> -200 = Half Cell Reading (mV) R=4.3 = Resistivity (kΩ.cm) ⊕ = Corrosion Potential Connection ▨ = Leakage ▩ = Delamination ▨ = Rust Staining
 (-123) = Half Cell Closing Reading (mV) 45 = Cover to Steel (mm) ⊗ = Dust Sample Location ▨ = Spalling ⊗ = Exposed Reinforcement



Plot Date : 17 July 2018 16:48:35
 File Name : K:\03 INSPECTIONS\GENERAL\CURRENT ASSET MANAGEMENT TEAM JOBS\SUTTON ON SEA COLONNADE WALL TESTING\SUTTON-ON-SEA TA SKETCHES

Project Title SUTTON-ON-SEA COLONNADE WALL 2018	Drawing Title CONCRETE TEST RESULTS TEST AREA 6 FRONT BEAM HALF JOINT	Purpose of issue -	THIS DOCUMENT HAS BEEN PREPARED PURSUANT TO AND SUBJECT TO THE TERMS OF AECOM'S APPOINTMENT BY ITS CLIENT. AECOM ACCEPTS NO LIABILITY FOR ANY USE OF THIS DOCUMENT OTHER THAN BY ITS ORIGINAL CLIENT OR FOLLOWING AECOM'S EXPRESS AGREEMENT TO SUCH USE, AND ONLY FOR THE PURPOSES FOR WHICH IT WAS PREPARED AND PROVIDED.		AECOM Infrastructure & Environment UK Limited Royal Court, Basil Close Chesterfield S41 7SL Tel: +44 (0)1246 209 221 Fax: +44 (0)1246 209 229 www.aecom.com
Client EAST LINDSEY DC		Designed - Drawn AS Checked ME Approved PH Date JUN 18 AECOM Internal Project No. 08251017 Scale @ A3 NTS Suitability - Zone / Mileage -	Drawing Number 011 Rev -		



NB: Chloride contents have been calculated assuming a cement content of 14%. Values shown for each test area are maximum negative half-cell potential and associated chloride content at reinforcement (corrosion potential readings taken less than 500mm above ground level are excluded)

Explanation of Good/Fair/Poor/Uncertain designations is included in "Interpretation of Results" section of this report.

SUMMARY OF MOST ONEROUS CORROSION POTENTIAL AND CHLORIDE ION TEST RESULTS

Based on Figure 1 in BD43
(Thresholds for impregnation and monitoring structures in service more than six years old)

FIGURE 8 - TEST AREA 6



TEST RESULTS



1535

AECOM Office	CHESTERFIELD	Client	EAST LINDSEY DC
Structure Name	SUTTON-ON-SEA COLONNADE WALL		
Structure Number	SOS	Site Survey Ref	24/5/18/11
Date of Survey	24/05/18	Surveyed By	M EVANS
Weather Conditions	SUNNY	Signature	<i>[Signature]</i>
Condition of Test Surface	DRY		
Temperature (°C)	17	Temperature Coefficient Applied to Results	NO
Connection Type	SCREW	Pre-wetted	YES

SEE DRAWING 012

	Location 1 – Front Beam (S4)			
Chloride ion content % by weight of concrete	Depth (mm)	%	Depth (mm)	%
	0-30	0.071		
	30-60	0.071		
	60-87	0.071		
Depth of Carbonation (mm)	N/A			
Reinforcement Cover (mm)	N/A			
Resistivity (kΩ.cm) Minimum	N/A			
Note: Laboratory determination of chloride ion content is carried out by a separately accredited external organisation, not AECOM.				
Structures Testing Manager's Signature		Test Area	TEST AREA 7	Between Columns J-K

Location Sketch & Readings

> -200 = Half Cell Reading (mV)
(-123) = Half Cell Closing Reading (mV)

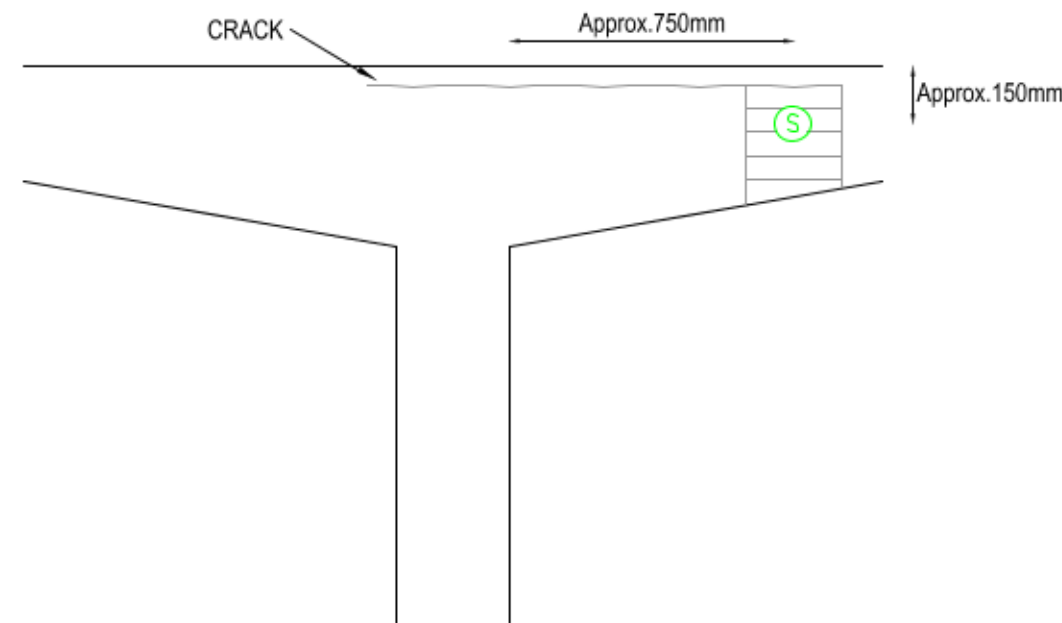
R=4.3 = Resistivity (kΩ.cm)
45 = Cover to Steel (mm)

Ⓢ = Corrosion Potential Connection
ⓈX = Dust Sample Location

☒ = Leakage
☒ = Spalling

☒ = Delamination
☒ = Exposed Reinforcement

☒ = Rust Staining



AREA OF RUST STAINING ON FRONT
BEAM, BETWEEN COLUMNS J-K

Project Title	SUTTON-ON-SEA COLONNADE WALL 2018
Client	EAST LINDSEY DC

Drawing Title	CONCRETE TEST RESULTS TEST AREA 7 AREA OF RUST STAINING BETWEEN COLUMNS J-K
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Purpose of issue				
-				
Designed	Drawn	Checked	Approved	Date
-	AS	ME	PH	JUN 18
AECOM Internal Project No. 08251017		Suitability -		
Scale @ A3 NTS		Zone / Mileage -		

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AECOM Infrastructure & Environment UK Limited	
Royal Court, Basil Close	
Chesterfield	
S41 7SL	
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