BUROHAPPOLD ENGINEERING

The Place

Structural Concrete Specification

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author	**Sara Lonsdale**
date	**23.01.17**
approved	**Andrew Tabern**
signature	
date	**23.01.17**

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BRITISH STANDARDS INSTITUTION

BS 5606 A guide to accuracy in buildings

BS 6089 Guide to assessment of concrete strength in existing structures

BS EN 13791:2007 Assessment of in-situ compressive strength

BS 8102 Code of Practice for protection of structures against water from the ground

BS EN 1992-1-1:2004 Eurocode 2: Design of concrete structures. General rules and rules for buildings

BS EN 1992-3:2006 Code of practice for design of concrete structures for retaining aqueous liquids

BS 8203:2001+A1:2009 Code of practice for installation of resilient floor coverings

BS 8204:2001+A1:2009 Screeds, bases and in-situ floorings

Part 1: Concrete bases and cement sand levelling screeds to receive floorings

Part 2:Concrete wearing surfaces

BS 8215:1991 Code of practice for protection of buildings against water from the ground

BS EN 13225 Precast concrete products. Linear structural elements

BS EN 13369 Common rules for precast concrete products

SPECIFICATION CLAUSES

This section is not included in the Common Arrangement of Work Sections but the requirements below form a part of the BuroHappold specification and MUST ACCOMPANY AND/OR BE READ WITH EACH AND EVERY FOLLOWING WORK SECTION together with Preliminaries and General Conditions.

1.1 GENERAL REQUIREMENTS/INFORMATION

1.1.1 100* General

Inspection And Acceptance of materials, contract drawings and workmanship by the CA, does not in any way relieve the Contractor of his responsibilities under the contract.

The Contractor is to review the detail of this specification and consider the times required for testing, preparation of samples, production of fabrication drawings and approval of information by the CA. This information to be included in the contract programme.

The contractor is to include in the price as necessary, the costs for all necessary test pieces, testing, trials and attendance to demonstrate compliance with the requirements of this specification.

All publications referred to hereafter are to be the issues current at the date of invitation to tender.

1.1.2 110* Arrangement Of Information

The different parts of in situ concrete construction are specified in separate sections as follows:-

- E10 In Situ Concrete Mixes, Casting And Curing
- E20 Formwork
- E30 Reinforcement
- E40 Designed Joints
- E41 Worked Finishes/Cutting

1.2 TOLERANCES

1.2.1 300 Tolerances

Except as noted below, concrete shall be placed within the range of deviation normally achievable for construction, as detailed in BS 5606:1990 except that no point or surface shall deviate from its nominal position or level by more than 20mm.

Ensure further that:

- All achieved sizes fall within the permissible deviations; and
- Two thirds of achieved sizes fall within one third of the permissible deviations

Generally

- Set out, erect components and apply finishes to ensure that there is a satisfactory fit at junctions and that the finished work has a well aligned, true and regular appearance.
- Ensure that there is an adequate exchange of information with and between all sub-contractors, suppliers and others employed by the Employer with regard to the sizes of components and locations.

- Check dimensions of all components after delivery to site and inform the CA of any departure from permissible deviations and tolerances.
- Any work which fails to meet the specific levels of accuracy, appearance and fit must be rectified at the Contractor's expense. Submit method statement to CA before rectifying work.

Where tighter tolerances are specified elsewhere in the documentation (i.e. in the Preliminaries, in other Sections of the Specification or on Drawings) then those tolerances take precedence.

1.2.2 310* Flatness Of Concrete Structural Floors

General:

Sudden irregularities not permitted. When measured with a slip gauge to BS 8204:Part 2, Figure 3 or equivalent, the variation in gap under a straightedge (with feet) placed anywhere on the surface to be not more than the following:

Floors which are to be self-finished, and floors to receive sheet or tile finishes directly bedded in adhesive:

- 5mm under a 3m straightedge
- 2mm under a 1m straightedge

Floors to receive screeds/toppings/beds up to 45mm thick:

- 10mm under a 3m straightedge

Ground Floor Slab:

Floor classification	**Property II limit (mm)**		**Property IV limit (mm)**	
	95%	100%	**95%**	100%
FM1	**2.5**	4.0	**4.5**	7.0
FM2	**3.5**	5.5	**8.0**	12.0
FM3	**5.0**	7.5	**10.0**	15.0

The Ground Floor slab is to be constructed to meet a Floor Classification of FM2, as stated in the above table taken from The Concrete Society Technical Report 34.

Measurement to confirm conformity to Property IV will be required and we reserve the right to request measurement for conformity to Property II. There is to be no/minimal level change between any day joints that may be required during the construction of the Ground Floor slab. Remedial grinding may be required.

1.2.3 311 Appearance And Fit

Arrange the setting out, erection, juxtaposition of components and application of finishes (working within the practical limits of the design and the specification) to ensure that there is satisfactory fit at junctions, that there are no practically or visually unacceptable changes in plane, line or level and that the finished work has a true and regular appearance.

Where satisfactory accuracy, fit and/or appearance of the work are likely to be critical or difficult to achieve, obtain approval of proposals or of the appearance of the relevant aspects of the partially finished work as early as possible.

1.2.4 320 Checking Tolerance

The Contractor shall check the concrete for compliance with specified tolerances at regular intervals during construction. Checking intervals to be chosen such that corrective action is not made more complex by subsequent construction.

BS 5606:1990; Section 13 - Control of Accuracy during Construction should be used for guidance.

Any instances of non-compliance with specified tolerances are to be reported to the CA, together with corrective action proposals.

1.2.5 330* Corrective Action

Proposals are to be agreed with the CA before proceeding.

Corrective action will be at the expense of the Contractor and will not be grounds for an extension of time.

1.3 CONTRACTOR SUBMISSIONS

1.3.1 Summary List Of Times For Contractors Submissions And Notice For Inspections

The submission or notice should reach the CA or his representative before the time stated.

Clause No	Item	Min Time of Submission or Notice
With respect to the works commencing on site:		
E05/100	Overall programme	2 weeks before
E20/120	Details of formwork	2 weeks before
E30/104	Method and programme for preparing reinforcement drawings and schedules	2 weeks before
E40/100	Construction joints, position and method	2 weeks before
With respect to the first relevant pour:		
E10/110	Nature and source of mix material	1 week before
E10/130 (4.3.2f)	Chloride content	2 weeks before
E10/230	Sulphate content	2 weeks before
E10/235	Sea dredged aggregates	2 weeks before
E10/240	Certification of cement alkali content	1 week before
E10/260	Samples of aggregate	1 week before
E10/270	Evidence of freedom from alkali silicate reaction	1 week before
E10/410	Mix design and evidence	2 weeks before
E10/480	Approval of admixtures	1 week before
E10/520	Name of Testing Authority	1 week before
E10/800	Curing Method	1 week before
E10/830	Method of maintaining concrete temperature	2 weeks before
E30/611	Reinforcement welding techniques	1 week before
E40/103	Pour sizes	3 weeks before
With respect to each relevant pour:		
E10/660	Final inspection before pour	2 days before

Clause No	Item	Min Time of Submission or Notice
E20/130	Propping arrangements if required	2 weeks before
E20/330	Holes, inserts and fixings required	2 weeks before
E30/100-110	Reinforcement details	2 weeks before
With respect to each test:		
E10-130 (4.3.2f) E10/230	Additional Test for chloride and sulphates	1 week after
E10/235	Additional tests	1 week after
E10/241	Test on water for mix if required	One day after completion of test
E10/530	Cube test reports	One day after completion of test
At the end of each week:		
E10/510	Records of concreting	
Immediately when noted:		
E10/580	Failure of any test	
E30/100	Discrepancies between bar schedules and drawings	
Made available for inspection throughout the contract:		
E10/120	Ready mix delivery notes	
E10/240	Cement certificates	
E10/510	Tests on fresh concrete and autographic batch records. Records of concreting	
E10/820	Daily temperature records	
E30/110	Reinforcement test certificate	

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REFERENCE DOCUMENTS

BRITISH STANDARDS INSTITUTION

BS 146 Specification for blast furnace cements with strength properties outside the scope of BS EN 197-1

BS EN 932-5:2000 Testing aggregates

BS EN 932-6:1999 Guide to sampling and testing aggregates

BS EN 932-1:1997 Methods for sampling

BS EN 933-1:1997 Flakiness index

BS EN 933-3:1997 Sieve tests

BS EN 933-7:1998 Method for determination of shell content in course aggregate

BS 812 Part 103:Section2: Sedimentation test

Part 105:Section2: Elongation index of course aggregate

BS 1881 Testing concrete

Part 112 Methods of accelerated curing of test cubes

Part 122: Method for determination of water absorption

Part 125: Methods for mixing and sampling fresh concrete in the laboratory

Part 201: Guide to the use of non-destructive methods of test for hardened concrete

BS 1881-114:1983 Methods of testing hardened concrete for other than strength

BS 1881-121:1983 Methods of testing hardened concrete for other than strength

BS 1881-122:1983 Methods of testing hardened concrete for other than strength

BS 4027 Specification for sulphate-resisting Portland cement

BS 6089 Guide to assessment of concrete strength in existing structures

BS EN 1992-1-1:2004 Eurocode 2: Design of concrete structures

BS EN 1992-3:2006 Code of practice for design of concrete structures for retaining aqueous liquids

BS 8500: Concrete

Part 1: Method of Specifying & Guidance for the Specifier

Part 2: Specification for Constituent Materials and Concrete

BS EN 197-1 Cement. Composition, specifications and conformity criteria for common cements

BS EN 206-1 Concrete - Specification, Performance Production and Conformity

BS EN 480 Admixtures for concrete, mortar and grout. Test Methods

BS EN 934 Admixtures for concrete, mortar and grout

BS EN 1008 Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete

BS EN 12350 Testing fresh concrete

Part 1:Sampling

Part 2: Sampling

Part 6: Density

Part 7: Air content. Pressure methods

BS EN 12390 Testing hardened concrete

Part 1: Shape, dimensions and other requirements for specimens and moulds

Part 2: Making and curing specimens for strength tests

Part 3: Compressive strength of test specimens

BS EN 12504 Testing concrete in structures

Part 2: Non-destructive testing. Determination of rebound number

Part 4: Determination of ultrasonic pulse velocity

BS EN 12620 Aggregates for concrete

BUILDING RESEARCH ESTABLISHMENT (BRE)

Digests:

330 Alkali aggregate reactions in concrete

357 Shrinkage of natural aggregates in concrete

Special Digest 1 Concrete in Aggressive Grounds

Information Pages

IP 7/87 Sea-dredged aggregates in concrete.

BRITISH CEMENT ASSOCIATION (BCA) (*FORMERLY CEMENT AND CONCRETE ASSOCIATION*)

48.037 Concrete Practice

"Concrete on Site" Series

"Appearance Matters" Series

Concrete Society

TR 18 A guide to the selection of admixtures for concrete

TR 22 Non-structural cracks in concrete

TR 30 Alkali silicate reaction: Minimising the risk of damage to concrete

SPECIFICATION CLAUSES

This section covers the manufacture, testing and use of structural quality insitu concrete and should be used in conjunction with the separate sections for formwork, reinforcement, worked finishes, joints etc.

For monolithic concrete toppings see Section E41.

To be read with preliminaries/General conditions and Section BH E05.

2.1 CONCRETE MIXES

2.1.1 110* Compliance With BS 8500

Constituent materials, composition of mixes, production of concrete, information to be provided, sampling, testing and compliance to be in accordance with BS 8500 unless otherwise specified.

The manufacturer's specification may be used with approval.

The nature and source of all materials is to be approved at least one week before the first relevant pour.

2.1.2 121* Ready-Mixed Concrete

Must be used for all concrete and must be obtained from a plant which holds a current Certificate of Accreditation under the Quality Scheme for Ready-mixed Concrete. Each mix must be obtained from only one source unless otherwise approved.

Each load to be accompanied by a delivery note stamped with the time of mixing and stating the consignee, concrete, grade and quantities of all materials in the mix including water and additives.

Not more than one hour to elapse between the time of mixing and the time of discharge.

All the constituents of each mix are to be added at the manufacturer's depot. No extra water or other material to be added after the concrete has left the depot.

Retain all delivery notes for inspection for the duration of the contract.

If the CA is not satisfied that the concrete complies with this specification he may alter the frequency of the sampling.

2.1.3 125* Sampling Frequency

First 40 samples: One sample for each $20m^3$ cast or four samples for each day that the mix is used, whichever is the greater.

Remainder: One sample for each $50m^3$ cast or one sample for each day that the mix is used, whichever is the greater.

The above relates to one source of concrete supply. Should a number of plants be used the as-stated sampling requirements shall be applied to each plant.

2.2 DESIGNED CONCRETE

2.2.1 128* Designed Mixes Given In This Specification To Comply With BS 8500

2.2.2 130* Mix Details

BS8500-1 Ref.	Requirement	Schedule
4.3.2 a	The concrete below shall be supplied as designed concretes in accordance with this specification and the relevant clauses of BS8500 –2	
	Concrete Reference	Ground Floor Superstructure
	Exposure Classification	AC-2s
	Minimum cover requirement (mm) X+Δc	50 (75mm un-blinded)
4.3.2 b	Compressive strength class	C32/40
4.3.2 c	For sulphate resisting concrete, design chemical class	DS-3 (DC-2)
	For other concretes, limiting values of composition:	
	Maximum water / cement ratio	0.45
	Minimum cement/combination content kg/m^3	360
4.3.2d and 4.3.3 a	Cement or Combination types	IIA-L or LL
	Other or special property,	
4.3.2 e	Maximum Aggregate Size, mm	20
4.3.2 f	Chloride class: Pre-stressed or heat cured reinforced concrete; Reinforced [1]; Unreinforced with no embedded metal;	RC
4.3.2 i	Consistency	S3

4.3.2 Note 2	UKAS or equivalent accredited third party product conformity certification	Yes
4.3.3b to n	Additional Requirements	
4.3.3c	Restrictions on the use of certain aggregates	No restrictions
Exchange of information		
BS EN 206-1, 7.1	Volume Required	Refer to CA
	Anticipated peak delivery rate	Refer to CA
	Any Access limitations	Refer to CA
5.1 a	Intended method of placing	Refer to CA
	Finishing	Basic Finish to clause E20/610
5.1 b	Where identity testing is routine:	
	Type of test	
	Volume of Concrete in assessment	Refer to 131
	Number of tests on this volume	Refer to 131
	Whether a non-accredited laboratory is used	Refer to CA
1 Where RC is specified, the chloride class shall be Cl 0.4 except where SRPC is used. In this case the chloride class shall be Cl 0.2		

2.3 STANDARDISED PRESCRIBED CONCRETE

2.3.1 140* Mix Details

BS8500-1 Reference	Requirement	Schedule

4.5.2 a	The concrete below shall be supplied as designed concretes in accordance with this specification and the relevant clauses of BS8500 – 2 and BS EN 206-1		
	Concrete Reference	Blinding concrete	Trench-fill
4.5.2 b	Standardized Designation	ST-2	FND2
	Is Concrete Reinforced	No	No
4.5.2 c	Maximum Aggregate Size (mm)	10	20
4.5.2 d	Slump Class	S3	S4
4.5.3 a	Restrictions on the types of cements or combinations permitted in BS 8500-2 Section 8.2		
4.5.3 b	Restrictions on the types of aggregates permitted in BS8500-2 Section 8.2		

2.4 CONSTITUENT MATERIALS

2.4.1 200 Precluded Materials

The following materials are specifically precluded from all specifications pertaining to works carried out under this contract:-

a) High alumina cement or concrete.
b) Woodwool slabs as permanent shuttering.
c) Calcium chloride in admixtures for use in reinforced concrete.
d) Asbestos in any form.
e) Sea dredged aggregates for use in reinforced concrete unless otherwise instructed by the client. (see Clause E10 235)
f) Calcium silicate bricks.
g) Urea formaldehyde.

The Contractor is required to ensure that all efforts be made, and using the best information available to him that these substances are not incorporated into the works. In the event that he is unwilling or unable to comply with these requirements he is to inform the CA in writing in sufficient time for consultations to be held and alternatives to be considered.

2.4.2 210 Test Laboratory

All specified testing of constituent materials to be carried out by an approved independent testing laboratory.

2.4.3 230* Sulphate Content Of Mixes

The total sulphate content of the constituents of each mix arising from all sources and expressed as SO3 must not exceed 4% by weight of the cement in the mix.

Submit certification and calculations to demonstrate compliance, before concreting work begins, and at intervals during the contract (as required by the CA).

2.4.4 235 Sea Dredged Aggregates

Will only be acceptable with the express approval of the Client. Acceptance will be dependent on additional sampling and testing of aggregates for chloride and sulphate content (See Clauses E10-130 4.3.2f (if Designed Mix) ; E10-150 4.4.2e (if Prescribed Mix); E10-230). Testing proposals are to be agreed with the CA before approval is given.

2.4.5 240 Cement

Type(s) as specified in the mix clause(s), manufactured by a BSI Registered Firm of Assessed Capability. Cement test certificates giving the BSI Registered Firm's Certificate Number to be obtained and kept on site for each consignment of cement delivered to the site. No cement is to be used before such a certificate, showing acceptable results, has been received.

To ensure uniformity cement in concrete for all works is to be obtained from a single source unless otherwise approved by the CA.

At least two weeks before the first relevant pour submit test certificates to show that the alkali content of the cement expressed as the sodium oxide equivalent, does not exceed 0.6% as determined by the method of BS 4550, Part 2.

The CA may call for tests from time to time and will reject any cement which is considered to have deteriorated from dampness or other causes.

With the Approval of the CA Pulverised Fuel Ash (to BS 3892) or Granulated Blast Furnace Slag may be permitted in designed mixes provided that the mix design makes full allowance for these and that all other specification requirements are satisfied.

2.4.6 241* Water

To be clean and free from harmful matter. If so directed the Contractor shall arrange for tests to be carried out in accordance with BS 3148.

2.4.7 250 Aggregates Generally

Types and sizes as specified in the mix clause(s), and complying with BS EN 12620 unless stated otherwise.

Sea dredged aggregates are not to be used unless otherwise instructed by the client. Where permitted they must comply with BS EN 12620 and/or BS 8110 as appropriate. See also clause E10/200 and E10/235 of this specification.

Obtain an undertaking from the suppliers of both coarse and fine aggregates of the type and quality selected, that sufficient quantities are available to complete the contract. To be approved by CA.

2.4.8 256 Recycled Aggregates – RCA Unless Noted Otherwise

All concrete mixes for concrete of Grade C40/50 or lower and subject to Exposure Classes X0, XC1, XC2, XC3, XC4, XF1 and DC1 are to contain 20% by mass RCA replacing coarse aggregate from natural sources, unless the contractor proves that the quality requirements will not be met, supply will not be available, or the cost will be significantly higher if RCA is used.

2.4.9 270 Aggregates Prone To Alkali-Silica Reaction

Submit evidence that the service records of the proposed cement/aggregate combinations extend over at least 5 years and do not include any instances of alkali/silica reaction.

If the CA is not satisfied with such evidence, or in its absence, concrete mixes must be made with:

EITHER

Cement with a certified average acid soluble alkali level less than 0.6% equivalent Na2O,

OR

A combination of not less than 50% PFA with OPC.

Specified concrete mixes which comply with any of these alternatives must not be changed without approval. Mixes containing a combination of GGBS or PFA with OPC must be obtained from a plant which holds a current Certificate of Accreditation under the Quality Scheme for Ready Mixed Concrete.

2.4.10 300 Drying Shrinkage Of Aggregates

To give a drying shrinkage of concrete not exceeding 0.045% when tested as in BRE Digest 357.

2.4.11 330 Aggregates-Submissions

At least two weeks before the first relevant pour all specified preliminary samples, results of specified preliminary test and required preliminary information on properties to be submitted and approved before making concrete for use in the works.

CA to retain all approved samples for comparison with subsequent deliveries. If any changes are proposed repeat all preliminary samples, tests and submissions and obtain approval of the change.

As required by the CA samples of the dry aggregates (from the site) to be tested for grading. Sampling and testing to be in accordance with BS 812, Clauses 3, 11 and 22.

The limits of acceptance for chlorides, clay, silt and dust will be those stipulated in Clauses E10-130 4.3.2f (if Designed Mix) ; E10-150 4.4.2e (if Prescribed Mix); E10-230) and E10-250 of this specification.

All aggregates to be washed with clean water prior to mixing.

Results of specified tests carried out during the progress of the works to be submitted to CA without delay, a copy to be retained on site.

2.4.12 340 Natural Aggregates - Preliminary Information

Submit details and source of supply, aggregate type and test results on the following properties as specified in BS 812 and BS EN 12620:

- Shape
- Water absorption value
- Flakiness and elongation
- Chloride ion content
- Grading

2.4.13 350 Air-Cooled Blastfurnace Slag/Clinker Aggregates - Preliminary Information

Submit evidence of compliance with BS EN 13055 and BS EN 1744 and other relevant British Standard(s).

2.4.14 351 Air-Cooled Blastfurnace Slag/Clinker Aggregates - Works Tests

During the progress of the works carry out tests selected by the CA from BS 812, BS EN 12620, BS EN 13055 and BS EN 1744; frequency of testing as instructed.

2.4.15 380* Storage Of Cement

Arrange delivery in suitably small consignments so that cement will be used within 4 weeks of delivery.

Use in order of delivery to site.

Store, in original bags, in weathertight structures having a raised, dry floor or in silos of approved design.

Reject any cement which has set such that it cannot be crumbled between the fingers.

2.4.16 390* Storage Of Aggregates

Store on hard paved self-drained areas or in approved hoppers or containers.

Each load to be checked by visual inspection before tipping.

Before mixing each batch to be visually inspected for consistency of particle shape, accuracy of grading, segregation of particle sizes and cleanliness. Aggregates containing clay or dirt will be rejected.

Ensure consistency of moisture content of fine aggregate at time of batching. If necessary allow stockpiles to drain for not less than 16 hours before use.

2.5 DESIGN/BATCHING AND MIXING

2.5.1 410 Evidence Of Suitability

For each designed mix, before making concrete for use in the works and whenever a change in the materials or the mix proportions is proposed, submit and obtain approval of:

- Nature and source of each material, grading curves for aggregates, all specified or proposed additives.
- Details of proposed quantities of each ingredient per cubic metre of compacted concrete and proposed workability.

EITHER

Appropriate existing data of not less than 40 samples as evidence of satisfactory previous performance for mean strength and current margin, workability, w/c ratio, drying shrinkage and any other requirements specified in Clause 130 et sec.

OR

Full details of tests on trial mixes as specified in BS 8110 and BS 8500 and BS EN206-1and tested according to BS 1181 to prove compliance with the Clause above.

OR

A statement that the mix is in full accordance with BS 8500 and BS EN206-1 and satisfies all the requirements of this specification.

2.5.2 431* Standardised Prescribed Concrete

The percentage, by mass of fine aggregate to total aggregate to be as follows

BS 882 grading limits Specification for lightweight aggregates for masonry units and structural concrete		**Nominal maximum size of aggregate**		
		40mm	**20mm**	**10mm**
Grades ST1, ST2, ST3	C, M or F	30/45	35/50	n/a
Grades ST4, ST5	C	30/40	35/45	45/55
	M	25/35	30/40	40/50
	F	25/30	25/35	35/45

In each case a range of fine aggregate percentage is given; the lower percentage is applicable to finer materials and the higher to coarser materials but in each case within the stated grading limits of BS 882.

Do not use BS 882 Specification for lightweight aggregates for masonry units and structural concrete grading limit F without approval.

For grades ST4 and ST5 and where high workability is required, check that the percentage of fine aggregate stated will produce satisfactory concrete if the grading of the fine aggregate approaches the coarser limits of grading zone C or the finer limits of grading zone F.

2.5.3 440 Cement Content

If the cement content of any designed mix is changed the CA must approve the change, and ensure that this does not result in non-compliance with any specified minimum or maximum cement content nor affect the attainment of the target mean strength.

2.5.4 450* Water Content

Water content of concrete must be carefully controlled and adjusted to allow for moisture content of aggregates to give consistent quality and workability.

2.5.5 460 Enrichment Of Mix

Subject to approval by the CA the aggregate:cement ratio may be reduced by up to 10% for the first layer of concrete in walls or columns. Do not alter the water:cement ratio.

2.5.6 470 Exposed Concrete

Obtain approval before altering proportions or grading of concrete which will be exposed in the finished work.

2.5.7 480* Admixtures

Use only if specified or approved. The following details of admixtures or cement containing additives to be submitted for approval:

- Brand name and manufacturers literature.
- Proposed dosage and detrimental effects, if any, of under and over-dosage.
- Chloride content.
- Method of adding to the concrete mix.

Pigments for colouring cement and concrete are to comply with BS EN 12878 ‘Specification for pigments for Portland cement and Portland cement products’.

Accelerators, retarders, water reducing admixtures and combinations of these are to comply with BS 480 and BS EN 934.

No substances containing chlorides are to be added to reinforced concrete.

Other approved admixtures are to be used strictly in accordance with the manufacturer's instructions.

Trial mixes to be made for all concrete containing admixtures.

2.5.8 481 Admixtures

Do not use in standard mixes.

2.5.9 490 General

All materials which have been damaged or are contaminated or unidentifiable or do not in all respects comply with the specification, will be rejected and removed immediately from the site at the Contractor's expense.

2.6 TESTING/CERTIFICATION OF CONCRETE

2.6.1 510* Complete Correlated Records

Must be maintained for each mix type, including:

- Source of concrete (i.e. plant name).
- Composition of the mixes tested, including any admixtures.
- All sampling and site tests.
- Identification marks or numbers of all specimens tested in the laboratory.
- The location of the part(s) of the structure represented by each sample.
- The location in the structure of the batch from which each sample is taken.
- Drawings to show each daily pour and the relevant cube test numbers for the pour.

2.6.2 520 Test Laboratory

All testing of concrete is to be carried out by one NAMAS Accredited laboratory. Submit the name of the selected laboratory to CA as soon as possible and in any case before making trial mixes or concrete for use in the works.

2.6.3 530 Test Reports

Two copies of reports are to be dispatched to CA within one day of completion of each test. Keep a complete set of reports on site.

2.6.4 540 Cube Test Reports

Must include at least the following:

- Test laboratory and name of person responsible.
- Source of concrete (i.e. plant name).
- Title of project.
- Identification number, numbers to be consecutive.

- Certificate of sampling.
- Certificate of method of making cubes.
- Curing place and conditions.
- Date of receipt by laboratory.
- Condition on receipt by laboratory.
- Actual or checked nominal dimensions.
- Weight and density.
- Date of test.
- Age when tested.
- Confirmation of testing to BS 1881 and BS EN 12350 & 12390
- Load at failure.
- Compressive strength.
- Type of fracture.
- Date of dispatch of report to CA.

2.6.5 550 Broken Cubes

Keep separately the pieces of any cube which fails to meet the compliance requirements for individual results. Obtain agreement of CA before discarding.

2.6.6 560 Compressive Strength

Cubes are to be 100mm or 150mm and cast in metal moulds.

2.6.7 561* Compressive Strength

Where ready-mixed concrete is being used, and where:

- there are less than 4 test results for a designed mix, or
- there is a lapse of 2 weeks or more between successive pours of a designed mix

the quality records of the ready-mix plant will be accepted in lieu of the specified testing for the mean strength from four results. The compliance for individual results will remain as specified.

2.6.8 570 Early Age Strength Testing

A regime of accelerated or normal curing and early testing of samples which is capable of predicting the 28 day strength of designed mixes may be used for determining compliance, subject to prior approval. If such a regime is adopted, two additional cubes must be made from each sample and cured normally so that, in the event of non-compliance, they can be tested at 28 days to provide information which will help in deciding the action to be taken.

2.6.9 580* Failures

If a concrete sample fails to achieve specified criteria or to pass specified tests, inform the CA without delay and submit:

- Confirmation of the validity of the test results, and/or
- Proposals for further tests to assess the strength of the concrete in the structure, as set out in BS 6089, and/or
- Proposals for rectification

Obtain approval of all such evidence and proposals before proceeding. The CA may issue instructions for the work to be stopped or delayed until reasons for the failure have been established, and the possible consequences assessed.

2.6.10 581 Failures

Wherever the specified sampling, testing and compliance procedures show that a concrete mix is not in accordance with the specification (even if the work is eventually accepted), and measures are taken to help in establishing whether or not the work is acceptable, such measures:

- will be at the expense of the Contractor, and
- will not be considered as grounds for extension of time.

2.6.11 590 In The Event Of The Failure Of A Test

The Contractor to notify the CA immediately and to carry out a full investigation into the cause. If the CA is not satisfied with the results of the Contractor's investigation or any additional tests which shall be carried out at the Contractor's expense, then the works made from the concrete mix between the times of the sampling for the previous and subsequent satisfactory tests, will be classed as defective work.

2.7 PLACING AND COMPACTING

2.7.1 610 Construction/Sequence/Timing Requirements

The Contractor is required to submit a method statement for all work associated with casting concrete.

2.7.2 620 Timing Of Watertight Construction

On hot and/or sunny days, either suspend placing of watertight concrete, or carry out placing during the late afternoon or evening. Other methods of keeping the concrete within an acceptable maximum temperature may be agreed with CA.

2.7.3 650* Cleaning

At time of placing ensure that all surfaces on which concrete is to be placed are clean with no debris, tie wire clippings, fastenings or free water.

2.7.4 660 Inspection

Give CA two days notice before each pour to allow inspection of reinforcement and surfaces against which concrete is to be placed.

2.7.5 670 Transporting

Avoid contamination, segregation, loss of ingredients, excessive evaporation and loss of workability. Cover concrete during excessive rain.

Clean all equipment used for mixing, transporting, placing and compacting immediately after use and whenever cement or aggregate is changed.

Use suitable walkways and barrow runs for traffic over reinforcement and freshly placed concrete.

2.7.6 680* Placing

CA to produce method statement outlining proposed pour sequence for Ground Floor slab, to be approved by Structural Engineer.

Record time, date and location of all pours.

Place while sufficiently plastic for full compaction. Do not add water or retemper mixes. Temperature at the time of placing must be not less than 5°C. Do not place against frozen or frost covered surfaces.

Place in final position in one continuous operation up to construction/day joints. Avoid formation of cold joints.

Do not discharge from an excessive height or through reinforcement or other obstructions in a way which may cause uneven dispersal, segregation or loss of ingredients. Use suitable chutes or trunking to place concrete where necessary.

Place in layers no thicker than can be effectively compacted with the equipment to be used.

Do not use vibrators to make concrete flow horizontally into position, except where necessary to achieve full compaction under void formers and cast-in accessories and at vertical joints.

2.7.7 690* Compacting

Start compacting as soon as there is sufficient concrete within the formwork to immerse the vibrator. Compacting to continue during the placing operation so that there is never a large volume of uncompacted concrete in the formwork.

Fully compact concrete to full depth (until air bubbles cease to appear on the top surface), especially around reinforcement, cast-in accessories, corners of formwork and joints.

Ensure amalgamation with previous batches but do not damage adjacent partially hardened concrete.

Use mechanical vibration for all concrete except strip footings and blinding.

2.7.8 700 Lightweight Aggregate Concrete

Place and compact so as to prevent the flotation of coarse aggregate and the formation of excessive blowholes.

2.7.9 720 Vibrators

All internal vibrators to be of a diameter appropriate to the works. Inform CA of the number and type of vibrators to be used. Provide standby vibrators. Do not use external vibrators without approval.

2.7.10 730 Plastic Settlement

At the top of deep sections and at significant changes in the depth of concrete sections, closely and continuously inspect the fresh concrete for signs of settlement during the first three hours after placing. While the concrete is still capable of being fluidized by the vibrator, re-vibrate as necessary to remove settlement cracking which may be forming either on the top surface or against the upper part of the vertical formwork.

2.8 CURING AND PROTECTION

2.8.1 800* Submission

At least one week before the relevant pour inform CA of the details of the proposed method of curing. All curing should be in accordance with BS 8110 Part 1 : Section 6.2.3.

2.8.2 810* Curing

Prevent surface evaporation from concrete throughout the period(s) specified below by:

- Retaining formwork in position and, if necessary, covering exposed surfaces immediately after striking, and
- Covering top surfaces of fresh concrete immediately after completion of placing and compacting each bay, removing covering only to permit any finishing operations and replacing immediately thereafter.
- Maintain surface temperature above 5°C throughout the periods specified below or four days, whichever is the longer.
- Maintain detailed records of location and timing of casting of individual batches, removal of formwork and removal of coverings. Keep on site for inspection.
- Allow for a central section of the Ground Floor slab to be cast initially and to contain Thermo-couples to allow monitoring of curing times

2.8.3 811* Curing

Coverings for curing may be suitable impervious sheet materials or a suitable curing compound with an efficiency of at least 75% and:

- Must be effective in preventing evaporation of water from the concrete, particular attention being paid to sealing at edges and junctions.
- Must not disfigure permanently exposed surfaces.
- Must not affect the satisfactory bond of subsequent construction and finishes.

Until the exposed top faces of fresh concrete are in a state suitable to receive sheets in direct contact or a sprayed curing compound as applicable, cover with waterproof sheeting held clear of the surface and well sealed against draughts at edges and junctions.

2.8.4 812* Curing

Prevent the build up of high temperatures and steep temperature gradients during the first 24 hours after casting, particularly in hot weather.

Prevent rapid changes in temperature during the first 7 days after casting.

Allow for a central section of the Ground Floor slab to be cast initially and to contain Thermo-couples to allow monitoring of curing times

Submit proposals designed to achieve these objectives (taking into account the nature of the design, the mix specification and the prevailing climatic conditions).

2.8.5 820 Curing Periods

CA to provide a method statement outlining proposals for the assessing curing times and controlling temperature and moisture dissipation.

Days (t = the average number of degrees Centigrade air temperature during the curing period):

	Concrete made using OPC, SRPC, RHPC	Concrete made using PPFAC, PBC, PFA, GGBS
Concrete surfaces which will be exposed to frost or chemical attack. Concrete wearing surface floors and pavements. Watertight concrete:		
Drying winds or dry sunny weather	140 t + 10	180 t + 10
Intermediate conditions	100 t + 10	140 t + 10
Damp weather, protected from sun and wind	100 t + 10	100 t + 10
Other structural concrete surfaces		
Drying winds or dry, sunny weather	80 t + 10	1 t + 10
Intermediate conditions	60 t + 10	80 t + 10
Damp weather, protected from sun and wind	No special requirements	No special requirements

Obtain prior approval for curing periods for mixes using admixtures or other types of cement.

2.8.6 840* Protection

Prevent damage to concrete, including:

- Surfaces generally: From site, indentation and physical damage.
- Surfaces to be exposed in the finished work: From dirt, rust marks and other disfiguration.
- Immature concrete: From thermal shock, physical shock, overloading, movement and vibration.

3 BH E20 - FORMWORK FOR IN SITU CONCRETE

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REFERENCE DOCUMENTS

BRITISH STANDARDS INSTITUTION

BS EN 1993 Design of Steel Structures

Part 4: Code of practice for design of composite slabs with profiled steel sheeting

BS EN 1992-3:2006 Code of practice for design of concrete structures for retaining aqueous liquids.

BS EN 1992-1-1:2004 Eurocode 2: Design of concrete structures

BRITISH CEMENT ASSOCIATION (BCA) (*FORMERLY CEMENT AND CONCRETE ASSOCIATION*)

48.037 Concrete Practice

"Construction Guide" Series

"Concrete on Site" Series

"Appearance Matters" Series

Construction Industry Research and Information Association

R136 Formwork striking times - criteria, prediction and methods of assessment

SPECIFICATION CLAUSES

This section deals with temporary or permanent formwork. General clauses on setting out and accuracy are included in Preliminaries Section A33.

To be read with Preliminaries/General conditions and Section E05.

3.1 GENERALLY/PREPARATION

3.1.1 100* General

The design of temporary formwork is the responsibility of the Contractor.

The design to be in accordance with BS EN 13670:2009

The systems proposed to be capable of sustaining the pressure due to compaction of fresh concrete without loss of grout.

Formwork to be sufficiently rigid to maintain its position, shape and profile so that the final concrete structure is within the limits of the dimensioning tolerances specified.

3.1.2 110 Loadings

Design and construct formwork to withstand the worst combination of:

- Total weight of formwork, reinforcement and concrete.
- Construction loads including dynamic effects of placing, compacting and construction traffic.
- Wind and snow loads.

Temporary formwork to be constructed of timber, sheet-metal or other approved material or to be lined such that the required standard of finish is produced.

Where timber formwork is used sealers are to be applied to surfaces which are dry, free from grit or other impurities and which have been sanded to remove protrusion or rough areas.

Damaged formwork will not be used if, in the opinion of the CA, making good would impair the surface appearance of the concrete.

3.1.3 120 Details

At least two weeks before work starts on site submit general details of the system (including propping) if required by CA.

3.1.4 130 Propping

Provide adequate propping to prevent deflection and damage to the structure. Carry down props to bearings strong enough to provide adequate support. This may require that it be carried down to the foundations or other suitable base. Not less than two weeks before the start of any pour requiring props the CA may require drawings showing the arrangement of proposed props and an estimate of the loads likely to be applied.

3.1.5 150 Bearings

Prop through other decks if construction load on a particular deck exceeds:

- the design loading, or
- where less than 28 days have elapsed from casting, a reduced loading agreed with CA.

Submit details of proposed prop bearings and through propping to CA

Accept responsibility for cost of checking effects on structure.

3.1.6 160 Cambers

Cambers shown on the drawings or specified below relate to the concrete immediately before formwork is struck. Make adequate allowance for deflection of formwork under weight of fresh concrete. Top surfaces of concrete must also be cambered to maintain the required structural depths and profiles.

Unless otherwise shown on drawings construct forms to achieve the following upward cambers:

Slabs: % of span measured at centre

0.1%

Beams: % of span measured at centre

0.2%

Cantilever beams: % of cantilever measured at free end

0.4%

After striking of formwork and removal of props check levels to determine extent of any residual camber and inform CA.

3.1.7 170* Work Below Ground

Vertical faces of strip footings, bases and slabs may be cast against faces of excavation, provided:

- Prior approval is obtained.
- The faces are sufficiently accurate and stable.
- Adequate measures are taken to prevent contamination of concrete.

Faces of walls must be cast against formwork.

3.1.8 190 Under-Slab Polythene Damp Proof Membrane

Before placing structural concrete (not blinding concrete) on hardcore or other absorbent strata, lay polythene damp proof membrane.

- Manufacturer and reference: Refer to Architect's specification
- Thickness: Refer to Architect's specification
- Lay membrane on a level bed of sand, not less than 13 mm thick.
- Double lock weld all edges and hold down with adhesive tape 150 minimum laps at edges.
- Adequately protect membrane from puncturing, and carefully repair any punctures which do occur.

3.1.9 191* Unspecified Damp Proof Membrane

Where a damp proof membrane is not specified, and structural concrete is to be placed on hardcore or other absorbent material, lay polythene sheet 1200 micron thick. Lap edges 150mm and seal with double sided tape.

3.1.10 210 Steelwork

Remove all loose millscale and loose rust before encasing in concrete.

3.2 CONSTRUCTION

3.2.1 310* Accuracy

Construct formwork accurately and robustly with adequate supports to produce finished concrete to the required dimensions. Formed surfaces must be free from twist and bow (other than any required cambers), all intersections, lines and angles being square, plumb and true.

3.2.2 320* Joints In Forms

Construct formwork, including joints in form linings and between forms and completed work, to prevent loss of grout, using seals when necessary. Secure formwork tight against adjacent concrete to prevent formation of steps. Joints in panels to be either vertical or horizontal unless otherwise specified.

3.2.3 330* Inserts, Holes, Chases

Confirm positions and details to ensure that alterations to and decisions about their size and location are not made without knowledge and approval of CA.

Fix inserts or box out as required in correct positions before placing concrete. Form all holes and chases. Cutting of hardened concrete without approval will be classed as defective work.

3.2.4 340 Kickerless Construction

All construction to be kickerless unless otherwise specified.

Unless shown otherwise for horizontal construction joints at base of walls and columns without kickers, using one of the methods described in BCA Publication 47.023 'Kickerless construction'. The Contractor must satisfy himself as to the suitability of the chosen method.

3.3 FORM TIES

3.3.1 350 Form Ties

Ties are to be approved proprietary ties. No metal part of any device for securing forms is to remain within the specified concrete cover.

3.3.2 430 Profiled Sheet Formwork and Reinforcement

Manufacturer and reference: Kingspan MD60 trapezoidal deck, or similar approved, to contractors design and specification.

3.3.3 440 Wood Wool Slab Permanent Formwork

Not permitted - see Section E10/200.

3.3.4 470 Release Agents

To be materials marketed as such and one of the following:

- Cream emulsion (not to be used where they may be subject to freezing).

- Neat oil with surfactant added.
- Chemical release agent.

Release agents must be stored and used strictly in accordance with the manufacturer's instructions.

Use the same type and make throughout the entire area of any one finish.

Use the minimum amount necessary to obtain a clear release and prevent excessive local collection.

Prevent release agent touching the reinforcement, hardened concrete, other materials not part of the form face and permanent forms.

3.3.5 480 Surface Retarders

Do not use without approval. Prevent retarder from touching the reinforcement.

3.4 STRIKING

3.4.1 510* Responsibility

Strike formwork without disturbing, damaging or overloading structure, and without disturbing props. Notwithstanding other clauses in this specification and any checking or approvals by the CA, the responsibility for safe removal of any part of the formwork and any supports without damaging the structure rests with the Contractor.

3.4.2 520 Minimum Periods

The following periods (in days) for retaining formwork in position before striking apply to ordinary Portland cement concrete with no cement replacement materials or admixtures:

	Average mean of daily minimum and maximum air temperatures during the period in degrees Celsius		
	16 °C	7 °C	3 °C
Vertical formwork to columns, walls and beams.	0.5	1	3
Soffit forms to slabs	4	7	10
Props to slabs	10	14	20
Soffit forms to beams	10	14	20

Props to beams	14	21	30

Submit details of proposed periods for mixes using admixtures or other types of cement.

3.4.3 521 Minimum Periods

Alternative methods of determining minimum periods for retaining formwork in position may be submitted for approval. Accept responsibility for cost of checking of proposals by CA and for any testing.

3.5 FORMED FINISHES

3.5.1 600 General

Unless otherwise directed no treatment of any kind except that required for curing the concrete and removing to be applied until they have been inspected by the CA. Concrete surfaces which will be exposed in the finished works to be protected from spillage, stains and other damage. Any finish work which will not meet the requirements or is any way inferior to the relevant approved trial panel or reference will be classed as defective work.

3.5.2 610 Basic Finish

No particular requirements, except those for tolerances and full compaction.

3.5.3 620 Plain Smooth Finish

Produce an even finish with a sheet material (e.g. plywood), with panels arranged in a regular pattern as a feature of the surface.

Abrupt irregularities to be not greater than 5 mm. Gradual irregularities, expressed as maximum permissible deviation from a 1 m straight edge, to be not greater than 5 mm.

Variation in colour resulting from the use of an impermeable form lining will be permitted but the surface to be free from discoloration due to contamination or grout leakage.

Blowholes less than 10 mm in diameter will be permitted but otherwise surface to be free from voids, honeycombing, segregation and other large defects.

Making good: Projecting fins are to be removed and rubbed down with a carborundum stone but otherwise the finish is to be left as struck. Making good of small defects will normally be permitted after inspection by CA and P&P

Arrisses to be to be chamfered with a 30mm wide corner face.

Formwork tie holes to be in an approved regular pattern, filled with matching mortar to an approved sample.

3.5.4 630 Fine Smooth Finish To Soffit of Precast Stairs

Produce a smooth even finish with an impervious sheet material (e.g. resin film faced plywood or steel), with panels/formwork arranged in an approved regular pattern. Do not replace parts of formwork panels where this may cause a change of colour in the concrete.

All formwork panels to be thoroughly cleaned prior pouring of concrete.

Abrupt irregularities to be not greater than 3 mm. Gradual irregularities, expressed as maximum permissible deviation from a 1 m straight edge, to be not greater than 3 mm.

Variation in colour resulting from the use of an impermeable form lining will be permitted but the surface is to be free from discoloration due to contamination or grout leakage.

Cover spacers: Do not use without approval.

Blowholes less than 5 mm in diameter will be permitted but otherwise surface to be free from voids, honeycombing, segregation and other defects.

Making good: Projecting fins are to be removed and rubbed down with a carborundum stone but otherwise the finish is to be left as struck. Making good of large areas will not normally be permitted.

Formwork tie holes to be in an approved regular pattern, filled with matching mortar to an approved sample.

4 BH E30 - REINFORCEMENT FOR IN SITU CONCRETE

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STRUCTURAL JOINTS		
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REFERENCE DOCUMENTS

BRITISH STANDARDS INSTITUTION

BS 1881 Testing concrete: Part 204 Recommendations on the use of electromagnetic covermeters

BS 4449 Specification for carbon steel bars for the reinforcement of concrete.

BS 4483 Steel fabric for the reinforcement of concrete.

BS 6744 Stainless steel bars for the reinforcement of and use in concrete. Requirements and test methods

BS EN 10080:2005 Steel for the reinforcement of concrete — Weldable reinforcing steel — General

BS EN 1992-1-1:2004 Eurocode 2: Design of concrete structures

BS EN 1992-3:2006 Code of practice for design of concrete structures for retaining aqueous liquids.

BS 8666 Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete

BS EN ISO 4066:2000

BS EN 1011 Welding. Recommendations for welding of metallic materials.

Part 1 General guidance for arc welding

Part 2. Arc welding of ferritic steels

BS EN ISO 1461 Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods

BS EN ISO 4066 Construction drawings. Bar scheduling

BRITISH CEMENT ASSOCIATION (BCA) (*FORMERLY CEMENT AND CONCRETE ASSOCIATION*)

48.037 Concrete Practice

"Construction Guide" Series

"Concrete on Site" Series

"Appearance Matters" Series

Concrete Society

CS101 Spacers for reinforced concrete - standard provision for achieving cover encircling reinforcing steel

BUILDING RESEARCH ESTABLISHMENT (BRE) Digests:

444 Corrosion of steel in concrete

305 Zinc-coated steel

DOCUMENTS FROM OTHER SOURCES

UK Certification Authority for Reinforcing Steels

Lists of Firms Holding CARES Certificates of Approval.

CONSTRUCT A guide to Contractor Detailing of Reinforcement in Concrete

SPECIFICATION CLAUSES

This section includes bar and fabric reinforcement for in situ concrete work. It does not cover:-

- Post tensioned reinforcement for in situ concrete.
- Profiled and ribbed steel formwork and reinforcement. Refer to Section E20.

To be read with Preliminaries/General Conditions and Section E05.

4.1.1 100* General

Contractor to check that reinforcement schedules have been provided for each part of the structure. This to be done sufficiently in advance of the concreting programme.

The types of reinforcement bars will be identified on the schedules by prefixes to the bar mark numbers as follows:-

R: Plain or deformed mild steel bars to BS 4449.

H: High yield bars to BS 4449. Bars deformed to comply with type 2 bond classification.

Before cutting any bars ensure that the schedule agrees with the reinforcement drawings.

Any discrepancies in shape, number, dimensions or grade to be brought to the attention of the CA immediately.

4.1.2 101 Design

The reinforced concrete shown on the designer's drawings and described in this specification has been designed to BS EN 1992-1-1:2004.

Reinforcement data and standard details provided on the BuroHappold drawings show the design intent only (primarily for RIBA stage 3 level pricing) and are not to be used for the direct placement of reinforcing bars.

The contractor will be required to carry out the full detailed design of all the structural concrete elements in accordance with BS EN 1992-1-1:2004 in order to determine the size and arrangement of all reinforcement required.

4.1.3 102 Placement Drawings And Bending Schedules

The Contractor is to prepare detailed placement drawings and schedules for the reinforcement.

In advance of preparing detailed reinforcement drawings and schedules, submit location drawings with individual members clearly identified and referenced.

Detailed placement drawings shall generally be in accordance with the following documents:

- 'Standard Method of Detailing Structural Concrete' published by the Institution of Structural Engineers
- BS EN 1992-1-1:2004.

All reinforcement scheduling to be in accordance with BS 8666.

The Contractor will be responsible for all dimensions shown on his drawings and schedules.

4.1.4 103 Drawing Review

The Contractor's drawings will be checked by the CA for compliance with the design. Schedules will not be reviewed and responsibility for co-ordinating the drawings and schedules will remain with the contractor.

Allow 10 working days for review and return of the drawings and schedules.

4.1.5 104 Drawing Programme

Before detailing and scheduling work commences, the Contractor is to submit for agreement his proposed programme for reinforcement detailing and scheduling. Allowance is to be made in the programme for approval of information by the CA. The Contractor should not submit more than 10 drawings per week.

4.1.6 105 Holes And Pockets

In slabs and walls, unless noted otherwise:

- Holes or pockets less than 150mm. Reinforcement local to these holes can be displaced during fixing.
- Holes or pockets greater than 150mm to be detailed by the contractor.

4.1.7 106 Holding Down Bolts/Cast-In Items

Reinforcement is to be co-ordinated with holding down bolt requirements by the Contractor (or other cast-in items).

4.2 REINFORCEMENT

4.2.1 110* Quality Assurance

All steel reinforcement specified to comply with BS 4449 or BS 4483 and cut and bent to BS 4466 or BS EN ISO 4066 is to be obtained from firm(s) holding a valid certificate of approval for the manufacture and/or fabrication of steel reinforcement issued under a third party quality assurance scheme operated by a certification body approved by the National Accreditation Council.

- Contractor to submit test certificates from an approved Testing Authority. Certificates are to include the manufacturer's identification mark as rolled into each brand of bar.
- Tensile tests for all bar sizes, bend and rebend tests for bars over 20mm diameter.
- Sampling and testing to be carried out in accordance with the appropriate clauses of BS 4449 for every 25 tonnes or part thereof of each diameter of reinforcement.

4.2.2 140* Plain Bar Reinforcement For Joints

To BS 4449, Grade 250.

4.2.3 150 Deformed Bar Reinforcement

To BS 4449, Grade 460.

4.2.4 210* Designated Fabric Reinforcement For General Use

Steel fabric to BS 4483, refer to BuroHappold Structural drawings.

4.2.5 250 Mechanical Damage

Reinforcement must not be roughly handled, dropped from a height, or subjected to shock loading or mechanical damage.

4.2.6 260* Cleanliness

Store reinforcement clear of the ground and prevent contamination by other materials. Keep each diameter separate. Steel fabric to be delivered and stored in flat sheets.

At time of placing concrete, reinforcement to be clean and free of corrosive pitting, loose millscale, loose rust, ice, oil and other substances which may adversely affect the reinforcement, concrete, or bond between the two.

4.3 CUTTING AND BENDING

4.3.1 310 Cut And Bend

Cut and bend reinforcement to schedules and to BS 8666. Do not rebend bars without approval. Reject consignment if reinforcement shows signs of fracture. Tag bundles of reinforcement with labels to BS 8666.

4.3.2 320 Galvanizing

Galvanising to BS EN ISO 1461, after cutting but before bending.

4.3.3 330 Adjustments

Provide on site facilities for hand bending to deal with approved minor adjustments.

4.3.4 340 Temperature Of Steel

Do not bend when below 5°C without approval. Steel may be warmed to not more than 100°C.

4.3.5 350 Stainless Steel

Cut and bend bars to BS 8666 as for high yield bars.

4.3.6 360 Projecting Reinforcement

Grade 250 bars may be bent to radii not less than BS 8666, Table 3. Grade 460 bars must not be bent or straightened without approval.

4.4 FIXING

4.4.1 410* Laps Or Splices

Obtain instructions if details are not shown on drawings.

4.4.2 420* Laps

Laps in nominal bar reinforcement to be not less than 300mm and as indicated on BH drawings.

4.4.3 421* Laps

Laps in fabric reinforcement where required to be not less than 250mm.

4.4.4 430 Electrolytic Action

Do not fix or place reinforcement in contact with nonferrous metals.

4.4.5 440* Fix Reinforcement

Fix reinforcement adequately, using tying wire, approved steel clips, or tack welding if permitted. Wire or clips must not encroach into the concrete cover.

4.4.6 450 Tack Welding

Do not tack weld unless authorised by the CA and recommended by the reinforcement manufacturer. Welding to be in accordance with BS 8110

4.4.7 460 Tying Wire For Use Generally:

Either:

- Black annealed mild steel wire 1.6mm diameter.
- Approved rustproof ties.
- Approved proprietary ties.

Ensure that the ends of the ties do not project into the concrete cover.

4.4.8 461 Tying Wire

For stainless steel reinforcement use annealed stainless steel wire, 1.6mm diameter (16 swg).

4.4.9 470 Cover

Not less than the nominal cover minus 5mm. Where reinforcement is located in a particular direction in relation to only one face of a member, not more than the nominal cover plus:

- 5mm on bars up to and including 12mm size.
- 10mm on bars over 12mm up to and including 25mm size.
- 15mm on bars over 25mm size.

4.4.10 480* Spacers

In addition to supports shown on drawings or schedules, provide spacers and chairs at not more than 1m centres or closer spacing as necessary to support reinforcement in position and maintain the specified cover. Reinforcement must be fixed in position before the concrete is placed. Cover spacers to be not closer than 300mm centres and staggered on adjacent parallel bars.

Submit details of the type of spacers to be used at least one week before concrete work starts.

4.4.11 490* Cover Spacers

Type(s) which will adequately support the reinforcement, resist displacement, not cause indentation of the formwork and made from:-

Plastics (perforated to at least 25% of their area), or fibre cement, or concrete (strength and durability to match surrounding concrete).

Concrete spacer blocks made on site are not permitted.

Spacers will not generally be permitted against a concrete face which will be exposed in the finished works.

4.4.12 491 Cover Spacers

Cover spacers to formed concrete finishes, if permitted (see section E41) to be approved type(s).

4.4.13 500 Damage

Prevent damage to and disfigurement of forms, form linings and adjacent work.

4.4.14 510 Rust Staining

Protect projecting reinforcement from the weather where rust staining of exposed concrete surfaces may occur. Prevent rust staining of formwork to surfaces of concrete which will be exposed to view in the finished work. CA to approve method proposed.

4.4.15 520 Checking Cover

Check the position of the reinforcement in the hardened concrete as soon as practicable after casting using a magnetic induction digital display type cover meter in accordance with manufacturer's recommendations and BS 1881:Part 204. Pay particular attention to columns, beams, cantilevers, soffits of slabs and all faces which will be exposed to the weather in the finished building.

4.4.16 521 Checking Cover

Check the position of the reinforcement in the hardened concrete as soon as practicable after casting using a magnetic induction digital display type cover meter in accordance with manufacturer's recommendations and BS 1881: Part 204. Pay particular attention to columns, beams, cantilevers, soffits of slabs and all faces which will be exposed to the weather in the finished building.

4.5 STRUCTURAL JOINTS

4.5.1 610 Structural Welded Joints

Will not be permitted.

4.5.2 621 Mechanical Joints

May be substituted for lapped joints subject to approval. Submit full details, including joint type(s) and location(s). Accept responsibility for cost of checking by the CA and for any supervision and testing.

4.5.3 650 Rejected Materials

Materials which are unidentifiable or do not comply with this specification will be rejected and immediately removed from the site at the Contractor's expense.

5 BH E40 - DESIGNED JOINTS IN IN-SITU CONCRETE

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Concrete Society 47

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REFERENCE DOCUMENTS

BRITISH STANDARDS INSTITUTION

BS 2499 Hot-applied joint sealant systems for concrete pavements

Part 2: Code of practice for the application and use of joint sealants

Part 3: Methods of test

BS 4449 Specification for carbon steel bars for the reinforcement of concrete.

BS 4483 Steel fabric for the reinforcement of concrete

BS 6093 Code of practice for design of joints and jointing in building construction.

BS 6213 Selection of constructional sealants

BS EN 1992-3:2006 Code of practice for design of concrete structures for retaining aqueous liquids

BS EN 14188 Joint fillers and sealants. Specifications for hot applied sealants

BRITISH CEMENT ASSOCIATION (BCA) (*FORMERLY CEMENT AND CONCRETE ASSOCIATION*)

"Construction Guide" Series

"Concrete on Site" Series

"Appearance Matters" Series

48.034 Concrete Ground Floors - A guide to their design and construction

48.037 Concrete Practice

97.325 Large area pours for suspended concrete slabs.

Architects' Journal

Element Design Guide: Substructure 4

Concrete Society

Design guidance on large area pours for suspended slab

TR34 Concrete industrial ground floors – a guide to their design and construction

CIRIA Report:

135 Concreting Deep Lifts and Large Pours

SPECIFICATION CLAUSES

Formation of joints in in-situ concrete is not a 'work section' in the normal sense as it comprises a number of elements and types of work which are operationally separate.

However it is customary to draw, measure and price designed expansion and contraction joints as separate entities so these are grouped here for convenience.

To be read with Preliminaries/General Conditions and Section BH E05.

5.1.1 100* General

The position and details of any construction joints not specified in the Contract to be approved by the CA. Submissions to be made at least two weeks prior to work commencing on site.

5.1.2 101 Quantities

The reinforcement quantities shown on the drawings are sufficient to control dry shrinkage cracking of concrete, provided that:

- The concrete is cured in accordance with good practice
- The size of concrete pours does not exceed the limit given below (Clause 102).

5.1.3 102* Pour Size Limits

The Contractor to comply with the following:

- Joints to be arranged so as to minimise the occurrence of shrinkage cracks.
- Except for watertight concrete the maximum size of pour to be 15m length and 200m2 in area, the ratio of the length of the sides is not to exceed 1:1.5.
- For watertight concrete the maximum pour to be 7m length and 50m2 area, the ratio of the length of the sides is not to exceed 1:1.5.
- In walls no pour is to exceed 4m height and 7m length.

5.1.4 103 Increasing Pour Size

The Contractor may increase the sizes of concrete pours provided that:

- The Contractor submits a method statement fully defining his proposal 14 days in advance.
- The Contractor adopts an appropriate concrete curing regime to eliminate plastic shrinkage cracking.
- The Contractor prepares and submits calculations to demonstrate that dry shrinkage cracking is limited to crack width of 0.2mm.
- The Contractor is to advise the CA what forces are induced in the existing structural elements and seek approval from the CA before proceeding.
- Any shrinkage cracking that does occur will be made good by the Contractor to the approval of the CA.
- The Contractor ensures that a concrete pour can be completed and finished without infringing restrictions on hours of working.
- Any costs or programme implications arising from these provisions will be absorbed by the Contractor.

Allow 10 days in the programme for approval of proposals by the CA.

5.1.5 105 Stop-Ends

All construction joints other than horizontal to be formed against proper stop-ends which are notched around the reinforcement, substantially grout-tight and fixed vertically unless otherwise directed.

Reinforcement not to be displaced or bent.

5.1.6 106 Workmanship

All laitance and honeycombed concrete to be removed from the contact face to expose the coarse aggregate.

This may be done by wire-brushing or pressure spraying. If scaling hammers or other mechanical devices are used these must not be so powerful as to damage the concrete by dislodging or fracturing the aggregate.

Before concreting is resumed the surface should be slightly wetted to assist adherence.

When concreting walls the mix properties for the first 250mm of concrete in contact with the horizontal joint should be altered by reducing the amount of coarse aggregate.

Special care to be taken to ensure full compaction against vertical surfaces and existing concrete.

5.1.7 110* Accuracy

All joints to be accurately located, straight and well-aligned, and truly vertical or horizontal or parallel with the setting out lines of the building.

5.1.8 120* Location Of Movement Joints

To be determined by the contractor. An indicative slab joint layout is shown on BuroHappold drawing S-102.

5.1.9 140* Construction Joints In Concrete Exposed To View

Joints additional to those required by the designer will not be permitted.

5.1.10 150* Construction Joints In Concrete Wearing Surface Floors

Joints additional to those required by the designer, will not be permitted.

5.1.11 210* Formed Joints

Construct using rigid, grout-tight side forms or stop ends designed to accommodate projecting bars or fabric without temporary bending or displacement.

5.1.12 211* Formed Joints In Concrete Wearing Surface Floors

Forms to be square edged with a steel top surface and in good condition.

Compact thoroughly at edges to give level, closely abutted joints with no lipping.

5.1.13 220 Precast Concrete Permanent Side Forms

Manufacturer and reference: As shown on BH drawings.

5.1.14 230* Roughening Of Contraction Joint Faces

Brush and spray surface of formed contraction joints while concrete is still green to leave a thoroughly roughened exposed aggregate finish.

5.1.15 300 Waterstops

The type of waterstop, whether specified or approved by CA, BB or BH for construction joints or movement joints to be used in accordance with the manufacturer's instructions. Contractor to obtain approval of the methods to be used to maintain them in their correct locations during placing of the concrete and after the removal of the formwork.

5.1.16 410 Tie Bars

To BS 4449, Grade 250, clean and free from loose millscale, loose rust, ice, oil and other deleterious substances..

Fix securely at the stated centres, at the required level, and centred on the joints.

5.1.17 420* Mesh Tie Strips

To BS 4483, clean and free from loose millscale, loose rust, ice, oil and other deleterious substances.

Fix securely at the required level with the width of the mesh strip centred on the joint.

5.1.18 430 Dowel Bars

To BS 4449, Grade 250, perfectly straight, with sawn (not sheared) ends.

Coat half of each bar with a suitable proprietary debonding compound or fit with a suitable plastics sleeve.

Fix bars securely at the required level, perfectly level, at right angles to and centred on the joint.

At expansion joints fit an approved type of cap incorporating not less than 20mm of compressible material to debonded ends of all bars.

5.1.19 520 Sheet Joint Filler For Expansion Joints

Manufacturer and reference: To contractors specification

5.1.20 521 Joint Sealant

To be suitable inert flexible material, that is to be installed in strict accordance with manufacturer’s recommendations. Colour grey. Contractor to obtain approval from CA of proposed type and supplier at least two weeks before start of relevant work on site. Submit proposals with tender.

5.1.21 530* Sealant For Joints In Slabs

Manufacturer and reference: To contractors specification

Prepare joints and apply sealant in accordance with manufacturer's instructions.

6 BH E41 - WORKED FINISHES TO IN SITU CONCRETE

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510 Chemical Surface Hardener 53

REFERENCE DOCUMENTS

BRITISH STANDARDS INSTITUTION

BS 410 Test Sieves

BS EN 12620 Aggregates for concrete

SPECIFICATION CLAUSES

This section deals with finishing operations on the surface of wet, set and hardened concrete. Formed finishes are included in Section BH E20, tolerance on features of in situ floors are specified in Section BH E05.

To be read with Preliminaries/General conditions and Section BH E05.

6.1.1 150* Timing

Carry out all finishing operations at optimum times in relation to the setting and hardening of the concrete – consult concrete supplier. Do not wet surfaces of concrete to assist surface working. Do not sprinkle cement on to surface.

6.2 TEXTURED FINISHES ON WET CONCRETE

6.2.1 210 Tamped Finish

Tamp surface with edge of a board or beam to give an even texture of parallel ribs.

6.3 SURFACE HARDENERS, SEALERS

6.3.1 510 Chemical Surface Hardener

Not less than three weeks after casting, clean surface of concrete by wetting with soap suds and scrubbing with wire brush and fine steel wool. Mop up and scrub with fibre brush and clean water. Allow to dry thoroughly for several days then apply an approved proprietary chemical surface hardener to manufacturer's recommendations.

Refer to manufacturer’s literature for appropriate timing of application of hardener.

Sara Lonsdale
Buro Happold Limited
2nd Floor, Eastgate
2 Castle Street, Castlefield
Manchester
M3 4LZ
UK

T: +44 (0)161 233 5000
Email: Sara.lonsdale@burohappold.com