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SPECIFICATION FOR READY-MIXED CONCRETE

PART 1 : REQUIREMENTS

SRI LANKA STANDARDS INSTITUTION

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SLS 1144 : Part 1 : 1996

Gr. 18

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Sri Lanka Standard
SPECIFICATION FOR READY-MIXED CONCRETE
PART 1 - REQUIREMENTS

FOREWORD

This Sri Lanka Standard specification was approved by the Sectoral Committee on Building and Construction Materials and was authorized for adoption and publication as a Sri Lanka Standard by the Council of the Sri Lanka Standards Institution on 1996 - 10 -17

Ready-mixed concrete is rapidly gaining popularity and many new producers are setting up business to cater for the increasing demand. This upsurge of interest can be mainly attributed to the convenience of its usage, and advantages outweighing the disadvantages of ready-mixed concrete in the local context.

Its advantages are:

i. Site space is saved and on restricted sites ready-mixed concrete is often the only way concrete can be made available;
ii. Responsibility for quality control is transferred to the producer who specializes in production of concrete;
iii. Concrete supply is unlikely to be interrupted as the producer will have adequate back-up resources;
iv. Site labour can be reduced and concrete can be conveyed and discharged at different parts of the site thus saving on distribution costs;
v. It is cheaper and less inconvenient to reject unsuitable concrete;
vi. Saving on operating, maintaining and manning a site mixing plant, which rarely works to its full capacity; and
vii. Well suited to sites where concreting takes place at infrequent intervals or in very large pours.

The disadvantages of ready-mixed concrete are:

a). Site roads and job access should be constucted to carry heavy large vehicles;
b). Deliveries may be late due to unforseen reasons such as slow traffic, accidents or breakdowns leading to disruption of site work;
c). Volume requirements should be assessed more accurately and well in advance of delivery;
d). Small amounts of concrete, for example for a base or a few kickers, can be expensive;
e). Cancellations should be made well in advance of delivery so that site requires reliable communication facilities with the producer;
f). Long delay caused by rejecting a load of concrete can have a serious effect on previously placed concrete;

g). Disputes are likely with producers who do not exercise quality control;
h). It may be expensive due to greater quality control and transport costs unless offset by savings in plant, workers and supervisory staff at site; and
i). Maintaining workability of mix right up to the time of placing requires admixtures and closer attention due to extended time of haul and evaporation.

Production of ready-mixed concrete is a complex operation. Further, for it to be viable, production should be done on a large scale. These requirements necessitate the implementation of rigid quality control measures at each stage of the production process from procurement of materials to delivary at site. Checking these measures is costly and may be out of reach of the small user while independent checking gives greater acceptance and fairer competition among different producers. Development of a Sri Lanka Standard on ready-mixed concrete and encouraging producers to obtain the SLS certification were considered timely for the development of greater confidence among users, thus encouraging further growth of this industry.

This part of the standard specifies the types, basis of supply, specification of concrete requirement, constituent materials, plant and equipment, production and delivery, inspection and records, and sampling, testing and compliance. Part 2 of this standard specifies test methods.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value observed or calculated, expressing the result of a test or an analysis shall be rounded off in accordance with CS 102. The number of significant places to be retained in the rounded off value shall be the same as that of the specified value in this standard.

The Sri Lanka Standards Institution gratefully acknowledges the use of the publications of the British Standards Institution, the American Society of Testing and Materials, the Bureau of Indian Standards, the Singapore Institute of Standards and Industrial Research, the Japanese Standards Association, the Standards Australia, the South African Bureau of standards, the Standards and Industrial Research Institute of Malaysia, and the National Bureau of Standards of China.

1 SCOPE

This part of the standard covers the requirements for supply of ready-mixed concrete in a freshly mixed and unhardened state requiring no further treatment before being placed. It does not cover placement, compaction, curing or protection of concrete after delivery to the purchaser.

2 REFERENCES

BS 12	Portland cement
BS 882	Aggregate from natural sources for concrete
BS 1370	Low heat Portland cement
BS 4027	Sulphate-resisting Portland cement
BS 5075	Concrete admixtures
BS 8007	Code of practice for design of concrete structures for retaining aqueous liquids.
CS 102	Presentation of numerical values
SLS 107	Ordinary Portland cement (Second Revision)
SLS 262	Methods of sampling, analysis and testing of concrete
SLS 522	Water for making concrete
SLS 728	Methods for testing of mineral aggregates for cement concrete mixes

3 DEFINITIONS

For the purpose of this specification the following definitions shall apply:

3.1 **admixture** : A product that is added to concrete or mortar, (in quantities which, except in special cases, do not exceed 5 per cent (m/m) of the cement) before or during the mixing or during an additional mixing operation, and that causes required modifications to the normal properties of the concrete or mortar.

3.2 **agitation** : The process of continuing the mixing of concrete at a reduced speed during transportation to prevent segregation.

3.3 **agitator truck** : Truck mounted equipment designed to agitate concrete during transportation to the site of delivery.

3.4 **batch** : The quantity of concrete mixed in one cycle of operations of a batch mixer, or the quantity of concrete conveyed ready-mixed in a vehicle, or the quantity discharged during 1 min, from a continuous mixer.

3.5 **batching** : The process of combining the concrete ingredients in fixed proportions by weight or by volume.

3.6 **cement content** : The mass in kilograms of cement contained in a cubic metre of fresh, fully compacted concrete.

3.7 **concrete** : A thoroughly mixed combination of cement, aggregates, and water with or without the addition of chemical admixtures or other materials.

3.8 **characteristic strength** : That value of strength below which 5 per cent of the population of all possible strength measurements of the specified concrete are expected to fall.

3.9 **delivery period** : The period, measured to the nearest 5 min, between the introduction of all or part of the mixing water into the cement-aggregate mixture, or of the cement into aggregate that is not completely dry, and the complete discharge at the point of delivery.

3.10 **designed mix** : A mix for which the purchaser is responsible for specifying the required performance and the producer is responsible for selecting the mix proportions to produce the required performance. With a designed mix, strength testing will form an essential part of the judgement of compliance.

3.11 **grade of concrete** : An identifying number for the concrete, the number being numerically equal to the characteristic strength at 28 days expressed in N/mm^2 in increments of 5 N/mm^2.

3.12 **mixer** : An item of plant or equipment in which the concrete ingredients are mixed.

3.13 **prescribed mix:** A mix for which the purchaser specifies the proportions of the constituents and is responsible for ensuring that the proportions prescribed will produce a concrete with the performance he requires. With a prescribed mix, strength testing will not be used to judge compliance.

NOTE

Indegenous prescribed mixes given in Table 7 for volume batching and prescribed mixes given in Table 6 for weigh batching are well known to develop the specified strengths. In delivering such a mix, producer is responsible for selection of consitituent materials, batching, mixing and delivery as specified in this standard.

3.14 **producer** : The person or authority entering a contract to supply concrete (e.g. a producer of ready-mixed concrete supplying a contractor).

3.15 **purchaser** : The person or authority entering a contract to buy concrete (e.g. a client or a contractor purchasing from a ready-mixed producer).

3.16 **ready-mixed concrete** : Concrete delivered at site or into the purchaser's vehicle in a plastic condition and requiring no further treatment before being placed in the position in which it is to set and harden.

3.17 **truck mixer** : A mixer generally mounted on a self-propelled chassis, capable of mixing the ingredients of concrete and of agitating the mixed concrete during transportation.

4 TYPES

For the purpose of this standard, the ready-mixed concrete shall be one of the three types, according to the method of production and delivery as specified in 4.1, 4.2 and 4.3.

4.1 Centrally-mixed Concrete

Concrete produced by completely mixing cement, aggregates, admixtures, if any, and water at a stationary central mixing plant and delivered in containers fitted with agitating devices, except that when so agreed to between the purchaser and the producer, the concrete may be transported without being agitated, in non-agitating equipment approved by the purchaser.

4.2 Truck-mixed Concrete

Concrete produced by placing cement, aggregates and admixtures, if any, other than those to be added with mixing water, in a truck mixer at the batching plant, the addition of water and admixtures to be added along with mixing water, and the mixing being carried out entirely in the truck-mixer either during the journey or on arrival at the site of delivery. No water shall be added to the aggregate and cement until the mixing of concrete commences.

4.3 Shrink-mixed concrete

Concrete that is first partially mixed in a stationary mixer and then mixed completely in a truck mixer. The time of partial mixing should be the minimum required to intermingle the ingredients. After transfer to a truck mixer, the amount of mixing necessary at the proper speed should be that required to produce concrete of the desired uniformity.

5 BASIS OF SUPPLY

5.1 Concrete Mix

The ready-mixed concrete shall be produced and supplied either as a designed mix (see 3.10) or as a prescribed mix (see 3.13).

5.2 Measurement of Ready-Mixed Concrete

5.2.1 The basis of supply shall be the cubic metre of plastic concrete as delivered to the purchaser.

5.2.2 The volume of plastic concrete in a given batch shall be determined from the total mass of the batch divided by the actual mass per m^3 of concrete. The total mass of the batch shall be calculated either as the sum of the masses of all materials, including water, entering the batch or as the net mass of concrete in the batch as delivered. If the purchaser wishes to verify the total mass of the batch, this shall be obtained from the gross and tare masses of the vehicle on a stamped weighbridge. The mass per m^3 shall be determined in accordance with the method given in 9 of SLS 1144:Part 2 : 1996.

NOTE

The in-situ measured volume may differ from the volume of plastic concrete as determined above, as a result of handling and compaction and the effects of hardening, temperature changes, formwork deflection, over-excavation, waste, some loss of entrained air (if any), settlement of wet mixtures, spillage and other relevant factors, none of which are the responsibility of the producer.

6 SPECIFICATION OF CONCRETE REQUIREMENTS

6.1 General

6.1.1 The purchaser shall specify the concrete requirements in terms of the following essential items (see also Appendix A):

a) Concrete mix, whether designed or prescribed;
b) The permitted type(s) of cement;
c) The permitted type(s) of aggregate;
d) Required nominal maximum size of aggregate;
e) Slump at the point of delivery;
f) Volume at the point of delivery;
g) Point of delivery and time(s) of delivery;
h) Procedure for accepting compliance in accordance with 11;
i) For designed mixes, the grade,specified in accordance with 6.2.1.2 and for prescribed mixes, the required mix proportions in kg of each constituent;
j) Minimum cement content in kg/m^3 of fresh fully compacted concrete in accordance with 6.2.1.2. In the case of prescribed mix, the purchaser shall ensure that the mix proportions are adequate to attain compliance with this requirement; and
k) Rate of sampling to be adopted for either strength testing (designed mixes) or composition testing (prescribed mixes) shall be in accordance with 11. The rate of sampling shall be indicated by quoting the number of cubic metres of concrete from which, on average, each individual sample shall be taken.

6.1.2 The purchaser shall, where necessary, specify the following optional items (see **Appendix A**):

a) Maximum free water/cement ratio;
b) Maximum cement content in kg/m^3 of fresh fully compacted concrete;
c) Special cements to be used;
d) Special requirements for aggregates;
e) Admixture(s) specified or prohibited and the quantity required;
f) Maximum and/or minimum temperature of the fresh concrete, if different from or additional to the limit in **6.8**; and
g) Any other requirements.

6.1.3 The form illustrated in Appendix B should be used as a standard form for specifying or ordering concrete.

6.2 Designed or Prescribed Mixes.

6.2.1 *Designed mix*

6.2.1.1 The mix shall be specified by its required performance in terms of a strength grade, subject to any restriction on materials, minimum or maximum cement content, maximum free water/cement ratio and any other properties required. Strength testing shall form an essential part of the assessment of compliance with the specification.

6.2.1.2 Appropriate strength grade shall be selected from Table 1. Minimum cement content and maximum water-cement ratio shall be selected from Table 2,Table 3 and Table 4. Above values shall be modified in accordance with Table 5, if concrete is exposed to sulphate attack.

6.2.1.3 A maximum cement content in excess of 550 kg/m^3 shall not be used unless special consideration has been given in design to the increased risk of cracking due to drying shrinkage in thin sections or to the thermal stressess in thicker sections.

TABLE 1 - Compressive strength grades.

Grade (1)	Designation (2)	Characteristic compresive strength at 28 days (N/mm^2) (3)	Lowest grade for compliance with appropriate use (4)
7	D7, P7V,P7W	7.0	Plain concrete as fill material
10	D10,P10V,P10W	10.0	Plain concrete for load transfer or as permanent shutter (screed concrete) for reinforced concrete
15	D15,P15W	15.0	Plain concrete in sea water or reinforced concrete using lightweight aggregates
20	D20,P20V,P20W	20.0	Reinforced concrete including reinforced concrete submerged in water or sea water
25	D25,P25V,P25W	25.0	Water retaining reinforced concrete
30	D30,P30V,P30W	30.0	Post-tensioned prestressed concrete
40	D40	40.0	Pre-tensioned prestressed concrete
50	D50	50.0	
60	D60	60.0	

NOTES

1. *D = Designed mix*
2. *PV = Prescribed mix for volume batching (see Table 7)*
3. *PW = Perscribed mix for weigh batching (see Table 6)*

TABLE 2 - Classification of exposure conditions

Environment (1)	Exposure conditions (2)
Mild	Concrete surfaces protected against weather or aggressive conditions
Moderate	Exposed concrete surfaces but sheltered from severe rain or freezing whilst wet Concrete surfaces continuously under non-aggresive water Concrete in contact with non-aggresive soil (see class 1 of Table 5) Concrete subject to condensation
Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing or severe condensation
Very severe	Concrete surfaces occasionally exposed to sea water spray or de-icing salts (directly or indirectly) Concrete surfaces exposed to corrosive fumes or severe freezing conditions whilst wet
Most severe	Concrete surfaces frequently exposed to sea water spray or de-icing salts (directly or indirectly) Concrete in sea water tidal zone down to 1 m below lowest low water
Abrasive	Concrete surfaces exposed to abrasive action, e.g. machinery, metal tyred vehicles or water carrying solids

NOTES

1. Deterioration of concrete by chemical attack can occur by contact with gases or solutions of many chemicals, but it is generally the result of exposure to acidic solutions or to solutions of sulphate salts.

2. Concrete made with Portland cements is not recommended in persistently acidic conditions (pH 4.5 or less). Concrete made with other cements such as supersulphated cement or cements based on ggbs or pfa can have some acid resistant properties.

TABLE 3-Guidance on mix design limits for durability of concrete made with normal weight aggregates of 20 mm nominal maximum size

Condition of exposure (1)	Type of concrete (2)	Maximum water/ cement ratio (3)	Minimum cement content kg/m³ (4)	Minimum grade (5)
Mild	Unreinforced non-structural	--	--	7
	Unreinforced structural	0.7	220	10
	Reinforced	0.65	230	20
	Prestressed	0.60	300	30
Moderate	Unreinforced non-structural	--	---	7
	Unreinforced structural	0.60	220	10
	Reinforced(Note2)	0.55	260	25
	Prestressed	0.55	300	30
Severe	Unreinforced non-strucural	0.60	220	10
	Unreinforced structural	0.55	280	20
	Reinforced	0.50	290	25
	Prestressed	0.45	330	30
Very severe	Unreinforced	0.50	300	20
	Reinforced	0.48	320	25
	Prestressed	0.45	330	30
Most severe	Unreinforced	0.50	300	20
	Reinforced	0.46	320	25
	Prestressed	0.40	330	30
Abrasive	Unreinforced	0.50	300	20
	Reinforced	0.45	320	25
	Prestressed	0.45	330	30

NOTES

1. Adjustments to minimum cement content should be made for aggregates of nominal maximum size other than 20 mm in accordance with Table 4.

2. For concrete made with normal- weight aggregate and used in foundations of low rise structure in non-aggressive soil conditions (moderate/reinforced), a minimum grade of 20 with a minimum cement content of 220 kg/m³ can be used.

3. For concrete containing embedded metal the values represent the minimum quality recommended and depend upon the provision of adequate cover. The relationships between quality of concrete and cover are given in relevant codes of practice.

TABLE 4 - Adjustments to minimum cement contents for aggregates other than 20 mm nominal maximum size.

Nominal maximum aggregate size in mm (1)	Adjustments to minimum cement contents in Tables 6 and 7 in kg/m³ (2)
10	+40
14	+20
20	00
40	-30

***NOTE** : The cement content should be not less than 230 kg/m³ for reinforced concrete or 300 kg/m³ for prestressed concrete, except as indicated by footnote 2 of Table 5.*

TABLE 5 - Concrete exposed to sulphate attack

Class	Concentration of sulphate expressed as SO_3			Type of cement	Dense fully compacted concrete made with 20 mm nominal maximum size aggregates[1] complying with BS 882 /BS 1047		Minimum grade
	In soil[2]		In ground water				
	Total SO_3	SO_3 in 2:1 water soil extract			Cement content not less than	Free water/ cement ratio not more than	
(1)	% (2)	g/L (3)	g/L (4)	(5)	kg/m³ (6)	(7)	(8)
C 1	Less than 0.2	Less than 1.0	Less than 0.3	Ordinary Portland cement	280	0.55	20
C 2	0.2 to 0.5	1.0 to 1.9	0.3 to 1.2	Ordinary Portland cement	330	0.50	25
				Sulphate-resisting Portland cement	280	0.55	20
C 3	0.5 to 1.0	1.9 to 3.1	1.2 to 2.5	Sulphate-resisting Portland cement	330	0.50	25
C 4	1.0 to 2.0	3.1 to 5.6	2.5 to 5.0	Sulphate-resisting Portland cement	370	0.45	30
C 5	Over 2	Over 5.6	Over 5.0	Sulphate-resisting Portland cement with adequate protective coating	370	0.45	30

(1) Adjustments to minimum cement content should be made for aggregates of nominal maximum size other than 20 mm in accordance with Table 4.

(2) If much of the sulphate is present as low solubility calcium sulphate, analysis on the basis of a 2:1 water extract may permit a lower site classification than that obtained from the extraction of total SO_3 . In such cases total SO_3 content should be used.

6.2.2 *Prescribed mix*

6.2.2.1 The mix shall be specified by its constituent materials and the properties or quantities of those constituents to produce a concrete with the required performance. The assessment of the mix properties shall form an essential part of the compliance requirements.

The purchaser shall provide the producer with all pertinent information on the use of the concrete and the specified requirements.

6.2.2.2 All the prescribed mixes are intended to be weigh batched.

Prescribed mixes given in Table 6 are developed for weigh batching. Water content may vary with the aggregates used and should be determined by trial and error to obtain the specified slump value.

Prescribed mixes given in Table 7 were originally developed for volume batching and used successfully over a long period of time. The proportions given in Table 7 are the volume proportions converted to weight proportions assuming:

(a) relative densities of ordinary Portland cement, fine aggregate and coarse aggregate as 3.15, 2.61 and 2.70 respectively; and
(b) bulk densities of ordinary Portland cement, fine aggregate and coarse aggregate as 1441, 1500, and 1450 kg/m^3 respectively.

Water-cement ratios are specified in Table 7, but if a given slump cannot be attained by the specified concrete mixture, cement slurry of the same water-cement ratio shall be added till attainment of the specified slump.

6.2.2.3 Table 7 gives mix proportions to attain the specified characteristic strength at 28 days but does not deal with durability. Hence the user should check whether the selected mix satisfies the requirements as regards minimum cement content, water-cement ratio and maximum cement content as specified in 6.2.1.2 and 6.2.1.3.

6.3 Slump of concrete

The workability of fresh concrete should be suitable for the conditions of handling and placing so that after compaction concrete surrounds all reinforcement, tendons and ducts and completely fills the formwork. Table 8 provides guidance on the workabilities appropriate for different uses. For most applications workability is specified by a slump value.

The selection of workability should normally be made by the purchaser of the fresh concrete who will need to specify the chosen test method and value to the producer, taking account of the permitted tolerance. (see **11.4.3**).

TABLE 6 - Prescribed Mixes for ordinary structural concrete by weigh batching

Concrete grade	Nominal max. size of aggregates (mm)	40		20		14		10	
	Workability	Medium	High	Medium	High	Medium	High	Medium	High
	Limits to slump that may be expected (mm)	50-100	100-150	25-75	75-125	10-50	50-100	10-25	25-50
7	Cement (kg)	180	200	210	230	--	--	--	--
	Total aggregate (kg)	1950	1850	1900	1800	--	--	--	--
	Fine aggregate (%)	30-45	30-45	35-50	35-50	--	--	--	--
10	Cement (kg)	210	230	240	260	--	--	--	--
	Total aggregate (kg)	1900	1850	1850	1800	--	--	--	--
	Fine aggregate (%)	30-45	30-45	35-50	35-50	--	--	--	--
15	Cement (kg)	250	270	280	310	--	--	--	--
	Total aggregate (kg)	1850	1800	1800	1750	--	--	--	--
	Fine aggregate (%)	30-45	30-45	35-50	35-50	--	--	--	--
20	Cement (kg)	300	320	320	350	340	380	360	410
	Total aggregate (kg)	1850	1750	1800	1750	1750	1700	1750	1650
	Sand*								
	Zone 1 (%)	35	40	40	45	45	50	50	55
	Zone 2 (%)	30	35	35	40	40	45	45	50
	Zone 3 (%)	30	30	30	35	35	40	40	45
25	Cement (kg)	340	360	360	390	380	420	400	450
	Total aggregate (kg)	1800	1750	1750	1700	1700	1650	1700	1600
	Sand*								
	Zone 1 (%)	35	40	40	45	45	50	50	55
	Zone 2 (%)	30	35	35	40	40	45	45	50
	Zone 3 (%)	30	30	30	35	35	40	40	45
30	Cement (kg)	370	390	400	430	430	470	460	510
	Total aggregate (kg)	1750	1700	1700	1650	1700	1600	1650	1550
	Sand*								
	Zone 1 (%)	35	40	40	45	45	50	50	55
	Zone 2 (%)	30	35	35	40	40	45	45	50
	Zone 3 (%)	30	30	30	35	35	40	40	45

* Sand is fine aggregate resulting from the natural disintegration of rock.

NOTES :

1. This gives weights of cement and total dry aggregates in kg to produce approximately one cubic metre of fully compacted concrete together with the percentages by weight of fine aggregate in total dry aggregates. The types of cement and aggregate used shall comply with this standard. Admixtures may reduce the water requirement necessary to attain the specified slump. The water requirement shall be determined by trial mixes to attain the required slump.

2. These mixes are prescribed mixes for weigh batching (see Table 1 for designations).

TABLE 7 - Indigenous Prescribed mixes for ordinary structural concrete.

Specified mix	Equivalent grade where specified	Quantities per 50 kg bag of cement				Fully compacted volume of concrete m^3
		Fine aggregate		Coarse aggregate		Approx. water content in litres
		m^3	kg	m^3	kg	
1.1.2	30	0.035	52.5	0.070	101.5	21	0.0946
1.1½.3	25	0.053	79.5	0.105	152.30	23	0.1259
1.2.4	20	0.070	105.0	0.140	203.0	25	0.1563
1.3.6	10	0.105	157.5	0.210	304.5	32	0.2210
1.4.8	07	0.140	210.0	0.280	406.0	32	0.2788

NOTES

1. *The internal dimension of boxes for measuring aggregate shall be 400 mm x 350 mm x 250 mm height.*

2. *If gauging boxes are allowed to be used for cement the corresponding box shall be 400 mm x 350 mm x 290 mm internal dimensions to account for bulking.*

3. *For values of physical properties used in computation, see 6.2.2.2 For greater accuracy, use the actual values of relative densities and bulk densities of cement, fine aggregate and coarse aggregate used in the concrete mix, when those values are available.*

4. *Weights of cement, fine aggregate and coarse aggregate in kg to produce approximately one cubic metre of fully compacted concrete can be obtained by direct proportionality based on the volume given in the last column.*

5. *These mixes are prescribed mixes for volume batching (see Table 1 for designations).*

TABLE 8. Workabilities suitable for different uses of in-situ concrete

Use of concrete (1)	Form of compaction (2)	Workability (3)	Nominal slump (mm) (4)
1. Plain concrete in pavements	Heavy vibration by power operated roller or tamper	Very low	10 - 25
	Poker/beam Vibration	Very low	10 - 25
	Tamping	Medium	50 - 75
2. Plain Concrete in foundations, footings,retaining walls and thick floors	poker/beam vibration	Very low	10 - 25
	Tamping or punning	Medium	50 - 75
3. Plain concrete in floors less than 75 mm in thickness, blinding	Poker/beam vibration	Low	25 - 50
	Tamping	Medium	75 - 100
4.Reinforced concrete in beams,slabs, walls, footings and columns	Poker vibration (for any element) or beam vibration (for slabs only)	Low	25 - 50
	Punning or Punning and tamping	Medium	50 - 100
5.Sliding formwork, pumped concrete	Poker or shutter vibration	medium	50 - 100

TABLE 8. Concluded

Use of concrete (1)	Form of compaction (2)	Workability (3)	Nominal slump (mm) (4)
6. Reinforced concrete thin sections or sections with congested steel	Poker vibration	Medium	50 - 75
	Punning	High	125 - 150
7. In-situ piling	Self weight compaction	High	125 - 150
8.Under water concre-ting, diaphragm walling and self levelling superplas-ticized concrete	Self levelling	Very high	150 - 200

NOTES

1. If truck mixers are to be used, slump of concrete should be at least 50 mm.

2. The slump of concrete for pumping should be at least 100 mm.

6.4 Quantity of concrete and delivery details

Total quantity of concrete required, time of first load, and rate of delivery are required by ready-mixed producer to plan his production and delivery functions efficiently. Local ready-mixed producers receive orders in cubic metres with a minimum quantity of 0.5 m^3 and increasing in increments of 0.25 m^3. But cost will depend on the need to achieve full truck capacity. The purchaser should decide on the rate at which he can handle and place the concrete. A typical order is "Total amount 60 m^3, first load at 9.00 a.m. and then at 10 m^3 per hour". Capacities of truck mixers (agitators) available locally are 3(3.75), 4(5.0), and 5(6.25)m^3.

Anticipated time for discharge and method of discharge will also help ready- mixed producer to plan his operations efficiently. Trucks can discharge at a rate of 0.5 m^3 per minute and a full load in five minutes. They should not be kept on site longer than thirty minutes and for longer periods a charge for waiting may be made. The most economic method is to discharge from truck into the formwork. Other methods are to discharge into a storage hopper, dumpers, crane skips, or a concrete pump. Maximum discharge level for the truck mixer chute is 1.5 m above ground and with the use of extensions, the discharge chute can cover a semi-circular working area of 2 m radius.

Trucks should be given easy access to the site. The normal size truck mixer is 8 m long x 2.5 m wide x 3.5 m high, weighs 24 tonnes with full load and has a turning circle of at least 15 m diameter. Enough space should be provided to allow the truck to be turned around. Roads and access points should be firm enough to carry the weight of the truck, even in very wet conditions. Access path should be clear of overhead cables that may foul the truck and shoring in nearby trenches should be sufficient to resist the effect of truck load. Truck needs wash-out facilities at site that will not cause a disruption to deliveries or nuisance to the general organization of the site.

6.5 Nominal Maximum size of aggregates

Normal maximum aggregate size is 20 mm, but if thin concrete sections are encountered a smaller value should be specified. It should not be larger than:

a) 1/5 the narrowest dimension between sides of forms;
b) 1/3 the depth of slabs ; and
c) 3/4 the minimum clear spacing between individual reinforcements.

Smaller maximum aggregate size will increase the cost and preferred sizes are 40, 20, 14 and 10 mm.

6.6 Concrete for pumping

Pumping concrete is economical only if it can be used over long uninterrupted periods as at the beginning of each period of pumping, the pipes should be lubricated by mortar and also because at the end of the operation considerable effort is required in cleaning the pipes. Concrete for pumping should contain a uniform continuously graded aggregate, and the sand proportion should be slightly greater (up to 4 per cent) than the optimum value for concretes handled by other methods. The cement content should be at least 300 kg/m^3 and the slump of concrete at least 100 mm. Maximum aggregate size should not exceed 1/3 of the diameter of the pipeline. The angular crushed stone coarse aggregate available in Sri Lanka will develop greater friction and hence a fairly high mortar content will be required. These concretes require water reducers or superplasticisers in addition to retarders.

6.7 Type of cement

Cement specified shall be one of those specified in 7.1, depending on the application.

6.8 Temperature

Temperature of concrete is particularly important for large concrete pours. If temperature is to be lowered considerably, but not less than 5 ^{0}C, aggregate should be chilled as mixing ice is not very effective.

7 CONSTITUENT MATERIALS

7.1 cement

Generally, ordinary Portland cement is used in Sri Lanka and the cement shall comply with SLS 107. If for special applications such as large concrete pours or concrete exposed to sulphate attack or concrete for early shutter removal, other cements like Low heat Portland cement (BS 1370) or sulphate- resisting Portland cement (BS 4027) or Rapid hardening Portland cement (BS 12) are to be used, the cement shall comply with the relevant British standard specification.

Wherever possible, cement should be obtained from a single source to avoid undue variation.

7.2 Aggregates

7.2.1 *Coarse aggregate*

Coarse aggregate shall be crushed stone usually of maximum size 20 mm, complying with BS 882. It shall be free from soft friable, thin, elongated or laminated pieces, coatings of dust and from clay, organic or any foreign matter.

For most work 20 mm aggregate is suitable. Where there are no restrictions to the flow of concrete between reinforcements and into sections, 40 mm or larger sized aggregate should be permitted. In concrete elements with thin sections, closely spaced reinforcement or small cover, consideration should be given to the use of 10 mm nominal maximum size. The preferred maximum sizes of aggregates are 40 mm, 20 mm, 14 mm, and 10 mm.

7.2.2 *Fine aggregate*

Fine aggregate shall be river sand, crushed stone fine aggregate or sea sand of size 5 mm to 150μm complying with BS 882. It shall be clean, sharp,and free of earth, silt,clay, loam, carbon, alkali, mica, organic matter and other deleterious substances.

Crushed stone fine aggregate shall be used only for designed mixes where high degree of quality control necessary can be made available to offset certain deficiencies of the crushed stone fine aggregate such as high dust content and poor grading without middle sizes. It should be manufactured from hard tough durable uncoated rock.

Sea sand should be washed, where necessary, to comply with the chloride limit specified in BS 882. When used for water retaining reinforced concrete, shell content of sea sand should not exceed 30 per cent by weight of dry aggregate as specified in BS 8007. This latter condition is unlikely to be critical for local sea sands.

7.3 Water

Water used for mixing concrete shall conform to SLS 522 and water of chemical composition acceptable for drinking, whether treated for distribution or untreated, is suitable for concrete production. Where public supply is not available, water may have to be obtained from natural sources which may contain undesirable organic constituents or unacceptably high contents of inorganic salts. Surface waters in particular often carry suspended matter such as oil, clay, silt, leaves, and other vegetable debris and may be unfit for use without physical treatments such as filtration or impounding to allow suspended matter to settle.

Highly coloured waters, those with a pronounced odour, those in which green or brown slime-forming algae are visible, or those contaminated by industrial effluent should be treated with suspicion. In essence, water should be potable, fresh, clear, clean and free from acid, alkali, oil, organic impurities, lime in solution or other matter which is deleterious to concrete or steel.

As a guide, SLS 522 recommends a pH value not less than 6 and the following concentrations to represent the maximum permissible limits of deleterious materials in water :

a). Suspended matter 2000 mg/litre

b). Dissolved matter

i	Sodium and potassium bicarbonates	1000 mg/litre
ii	Sodium chloride	20000 mg/litre
iii	Sodium sulphate	10000 mg/litre
iv	Calcium and magnesium bicarbonates	400 of HCO_3 mg/litre
v	Calcium chloride	20000 mg/litre
vi	Iron salts	40000 mg/litre
vii	Sodium iodate, phosphate, arsenate and borate	500 mg/litre
viii	Hydrochloric and sulfuric acids	10000 mg/litre
x	Sodium hydroxide	5000mg/litre

Water containing quantities of substances which discolour it or makes it smell or taste unusual or otherwise cause suspicion on physical examination, shall be tested in accordance with SLS 522. It is considered acceptable if the variation of initial setting time is within $\pm$ 1/2 hour, and 28 day compressive strength is not reduced below 80 per cent, when distilled water of the specified tests is replaced by water in question..

Wash water from mixer washout operation shall not be used as mixing water in the production of concrete.

7.4 Admixtures

Admixture is unlikely to make poor concrete any better and is not a substitute for good mixing. It can aid compaction,make placing easier, help faster shutter removal or alter the hardened concrete. The use of an admixtures should be viewed as a way of producing a more durable concrete or as a way of assisting in obtaining better concrete under extreme or unusual conditions. The more common types are : accelerators, retarders, water reducers, air-entraining agents, superplasticisers and combinations of water reducer/super-plasticiser/retarder (such as water reducing retarder and retarding superplasticiser). Less used types are : gas-forming, grouting, expansion producing, bonding, pumping aids (thickeners to improve cohesiveness),colouring, flocculating, fungicidal, germicidal, insecticidal, damp-proofing, permeability-reducing, alkali-aggregate expansion reducing, and corrosion inhibiting admixtures.

Accelerators are used to speed up the rate of chemical reaction between cement and water, thus causing concrete to set sooner and develop early strength quicker. They can be useful in the precast industry. As calcium chloride has fallen out of favour, calcium formate, calcium nitrate and triethanolamine are used as accelerators.

Retarders are used to slow the setting time of cement in following situations:

(i) in large pours taking several hours; (ii) in slipform work to provide longer period needed between successive pours; and (iii) when long delays between mixing and placing are anticipated as when ready-mixed concrete is supplied by a long journey or through an area with heavy traffic. They may affect 24-48 hour strength. Sugar, carbohydrate derivatives, soluble zinc salts and soluble borates are used as retarders.

Water reducers are surface-acting chemicals leaving a lubricating effect, causing cement particles to become negatively charged, that allows a reduction of water for given workability. As they may also allow a reduction of cement content, care is needed in their use as minimum cement content should be maintained for durability. Lignosulphonic acids and their salts, and hydroxylated carboxylic acids and their salts are used as water reducers.

Air-entraining agents are used to increase the resistance of hardened concrete to frost damage and de-icing salts. Hence, they are not relevant to Sri Lanka. Salts of wood resins, synthetic detergents, salts of sulphonated lignin, salts of petroleum acids, salts of proteinaceous materials, fatty and resinous acids and their salts, and organic salts of sulphonated hydrocarbons are used as air-entraining agents.

Superplasticisers can increase the slump of concrete from about 75 mm to about 200 mm without affecting the strength or causing segregation or bleeding, and hence they are used in concrete for pumping. They are really high range water reducers and consist of either sulphonated melamine formaldehyde condensates or sulphonated napthalene formaldehyde condensates. These concretes may exert full hydrostatic pressure on formwark and some recent formwark failures in Sri lanka are attributed to this.

For concrete production in Sri Lanka, accelerators may be necessary in applications which require high early strength, while water reducers or superplasticisers may be necessary in applications where compaction by mechanical means is difficult or is not possible. Ready-mixed concrete requires retarders and, when pumping is involved, water reducers or superplasticisers. For normal concretes (other than concrete subjected to frost/de-icing salts or concrete for pumping with marginal sand lacking in fine materials) air-entraining agents are not preferred, but if used air content should be well controlled. Admixtures shall only be used when so agreed between the producer and the purchaser and those agreed shall comply with BS 5075 (Part 1 and Part 3). To seek agreement for the use of an admixture following data shall be supplied:-

a) The typical dosage and details of the detrimental effects of under-dosage and over-dosage;

b) The chemical name(s) of the main active ingredient(s) in the admixture;

c) Whether or not the admixture contains chlorides and, if so, the chloride ion content of the admixture expressed as a percentage mass of cement in the mix;

d) Whether or not the admixture leads to the entrainment of air when used at the admixture manufacturer's recommended dosage;and

e) Where more than one admixture is used, the compatibility of the admixtures.

7.5 Storage and handling of materials

7.5.1 *Cement*

Bins or silos of cement shall be weather-proof and permit free flow and efficient discharge of cement. Each shall be capable of being cleaned out thoroughly and inspected internally. Each bin or silo shall be fitted with an independent regularly cleaned filter,or other method of dust control, sufficient to allow the delivery to be maintained at the correct pressure and properly maintained to prevent interference with weighing accuracy by build-up of pressure.

Bagged cement shall be stored in a such a manner that it will not become damp either from the weather or from the ground. The store shall be managed so that the cement is used in the same order as it is delivered.

7.5.2 *Coarse and fine aggregates*

Each nominal size and type of aggregate shall be stored separately. Storage and handling shall be arranged to avoid contamination, minimize segregation and prevent intermingling with adjacent material. The floor shall be constructed of concrete and measures shall be taken for drainage as well as prevention of ingress of foreign matter.

7.5.3 *Water*

Where bulk storage of water is required, it shall be stored in a manner which will prevent contamination by matter deleterious to concrete. Water used in the production of concrete shall be protected from contamination.

7.5.4 *Admixtures*

Admixtures shall be properly and clearly marked with due attention given for preserving the legibility of identifying labels. Each admixture shall be stored separately in a manner which will prevent deterioration and accidental misuse of or contamination of, or by, other concrete constituent materials. In the case of liquids, adequate provision shall be made to prevent precipitation and segregation, and to protect from extremes of temperature. For any liquid admixture which is not stable in solution, agitation should be provided.

Where a container is intended to be re-used for the same or a different type of admixture, it shall be capable of being cleaned out thoroughly and inspected internally.

It is important for the admixture to be dispersed evenly throughout the concrete and the most effective way is to add the liquid admixture into the mixing water before it goes into the mixer. Where this is not possible, the concrete should be mixed longer to ensure even distribution.

7.6 **Measurement of materials**

All measuring equipment shall be maintained in a clean and serviceable condition. The weighing devices shall be zeroed daily, checked for accuracy monthly and calibrated quarterly.

Cement shall be weighed to an accuracy of $\pm$ 3 per cent of the weight of cement in the batch.

Coarse aggregate shall be weighed to an accuracy of ± 3 per cent of the required weight of coarse aggregate in the batch. Moisture content, if any, in the coarse aggregate should be noted in order to make suitable adjustments to the quantity of water to be added. Fine aggregate shall be weighed as treated similar to the coarse aggregate as specified above.

Mixing water shall consist of water added to the batch, ice added to the batch, water occurring as surface moisture on the aggregates, and water introduced in the form of admixtures. The added water shall be measured by weight or volume to an accuracy of ± 1 per cent of required total mixing water, in the batch. Added ice shall be measured by weight. In the case of truck mixers, any wash water retained in the drum for use in the next batch of concrete shall be accurately measured. If this proves impractical or impossible, the wash water shall be discharged prior to loading the next batch of concrete. Total water (including any wash water) shall be measured or weighed to an accuracy of ± 3 per cent of the specified total amount.

Powdered admixtures shall be measured by weight, while paste or liquid admixtures shall be measured by weight or volume. Accuracy of measurement shall be within ± 3 per cent of the amount to be added to the batch by weight or volume.

8 PLANT AND EQUIPMENT

8.1 Batching Plant

Bins with adequate separate compartments shall be provided in the batching plant for fine and for each required size of coarse aggregate. Each bin compartment shall be designed and operated so as to discharge efficiently and freely , with minimum segregation, into the weighing hopper. Means of control shall be provided so that, as the quantity desired in the weighing hopper is approached, the material may be shut off with precision. Weighing hoppers shall be constructed so as to eliminate accumulations of tare materials and to discharge fully.

Indicating devices shall be in full view and near enough to be read accurately by the operator while charging the hopper. The operator shall have convenient access to all controls.

Scales in use shall be accurate when static load tested to ± 0.4 per cent of the total capacity of the scale.

Scales for batching concrete ingredients may be either beam or springless dial scales and shall be capable of satisfying the weighing tolerances given in 7.6. Methods for weighing (electric, hydraulic, load cells, etc.) other than beam or springless dial scales which meet the above weighing tolerances are also acceptable.

Adequate standard test weights shall be available for checking accuracy. All exposed fulcrums, U-hooks and similar working parts of scales shall be kept clean. Beam scales shall be equipped with a balance indicator sensitive enough to show movement when a weight equal to 0.1 per cent of the nominal capacity of the scale is placed in the batch hopper. Pointer travel shall be a minimum of 5 per cent of the net-rated capacity of the largest weigh beam for underweight and 4 per cent for overweight.

The device for the measurement of the added water shall be capable of delivering to the batch the quantity required within the accuracy required in 7.6. The device shall be so arranged that the measurements will not be affected by variable pressures in the water supply line.

Faucet and glass tube shall be equipped outside the tank to measure the water content in the tank, unless other methods can be applied to measure the water content in the tank accurately.

8.2 Mixers and agitators

8.2.1 Mixers may be stationary mixers or truck mixers. Agitators may be truck mixers or truck agitators.

Stationary mixers shall be equipped with a metal plate (see Figure 1) or plates on which are plainly marked the mixing speed of the drum or paddles, and the maximum capacity in terms of the volume of mixed concrete. When used for the complete mixing of concrete, stationary mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed.

Each truck mixer or agitator shall have attached thereto in a prominent place a metal plate (see Figure 2) or plates on which are plainly marked the gross volume of the drum, the capacity of the drum of container in terms of the volume of mixed concrete, and the minimum and maximum mixing speeds of rotation of the drum, blades, or paddles. When the concrete is truck mixed as described in 4.2 or shrink mixed as described in 4.3, the volume of mixed concrete shall not exceed 63 per cent of the total volume of the drum or container. When the concrete is central mixed as described in 4.1, the volume of concrete in the truck mixer or agitator shall not exceed 80 per cent of the total volume of the drum or container. Truck mixers and agitators shall be equipped with means by which the number of revolutions of the drum, blades, or paddles may be readily verified.

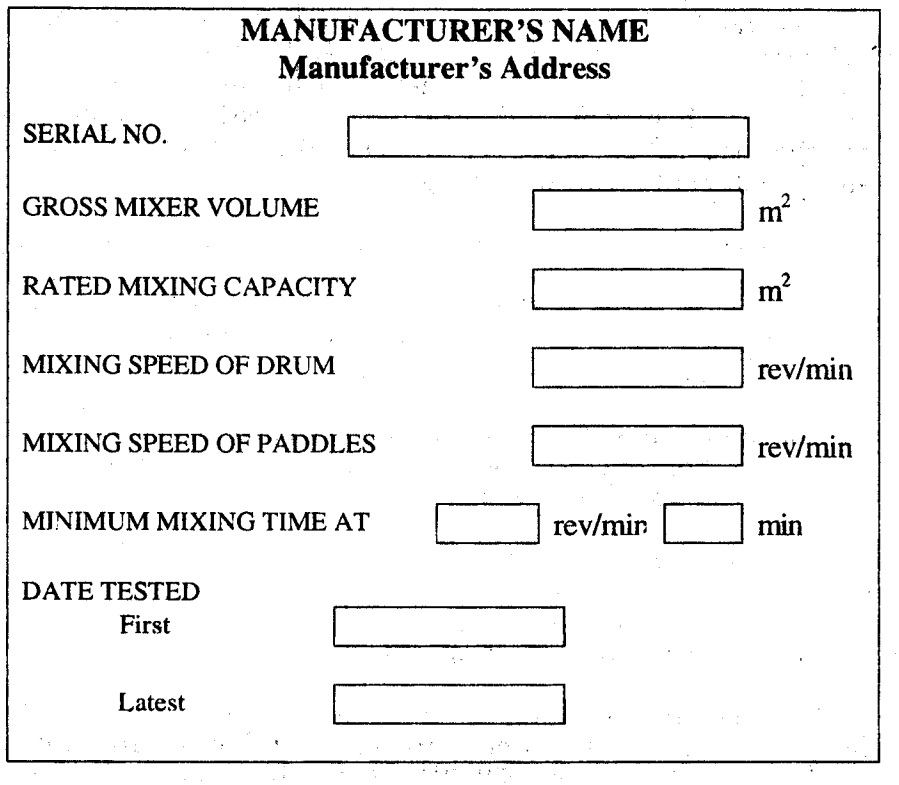

FIGURE 1 - Sample identification plate for stationary mixers

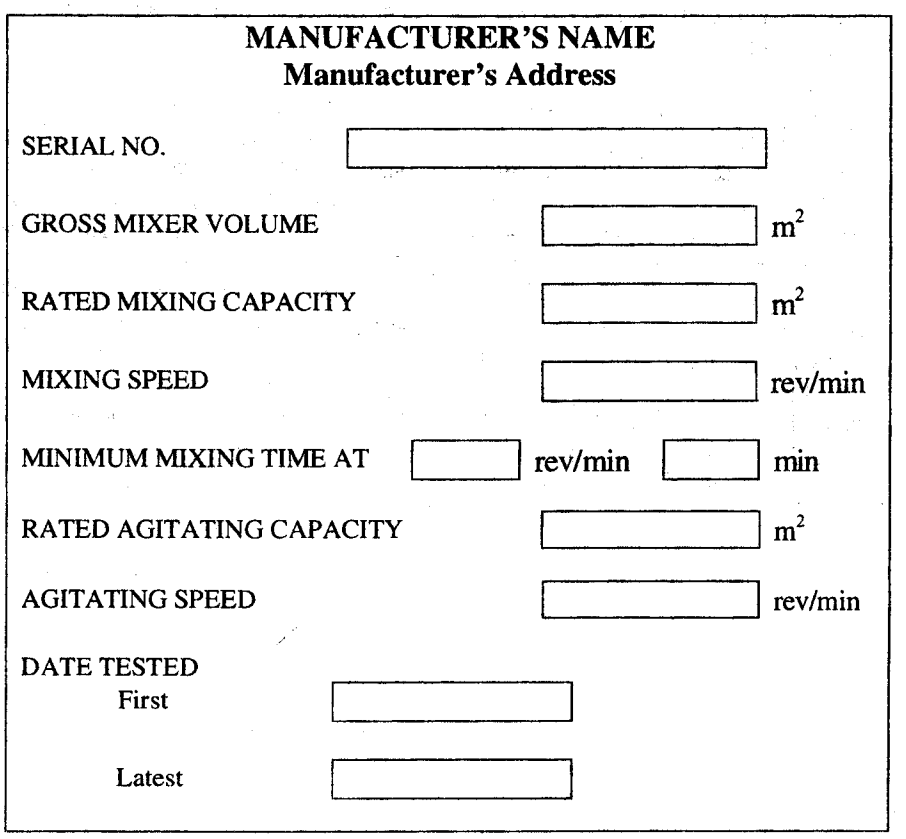

FIGURE 2 - Sample identification plate for truck mixer or agitator.

8.2.2 All stationary and truck mixers shall be capable of combining the ingredients of the concrete within the specified time or the number of revolutions specified time in 8.2.5, into thoroughly mixed and uniform mass and of discharging the concrete so that not less than 5 of the 6 requirements shown in Table 9 shall have been met.

NOTE

The sequence or method of charging the mixer will have an important effect on the uniformity of the concrete.

8.2.3 The agitator shall be capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity as defined in Table 9.

8.2.4 Slump tests of individual samples taken after discharge of approximately 15 per cent and 85 per cent of the load may be made for a quick check of the probable degree of uniformity. These two samples shall be obtained within and elapsed time of not more than 15 min. If these slumps differ more than that specified in Table 9, the mixer or agitator shall not be used unless the condition is corrected, except as provided in 8.2.5.

NOTE
No samples should be taken before 10 per cent or after 90 per cent of the batch has been discharged. Due to the difficulty of determining the actual quantity of concrete discharged, the intent is to provide samples that are representative of widely separated portions, but not the beginning and end of the load.

8.2.5 Use of the equipment may be permitted when operation with a longer mixing time, a smaller load, or a more efficient charging sequence will permit the requirements of Table 9 to be met.

8.2.6 Mixers and agitators shall be examined or weighed routinely as frequently as necessary to detect changes in condition due to accumulations of hardened concrete or mortar and examined to detect wear of blades. When such changes are extensive enough to affect the mixer performance, the proof-tests described in Table 9 shall be performed to show whether the correction of deficiencies is required.

TABLE 9 - Requirements for uniformity of concrete

TEST (1)	Requirement, expressed as maximum permissible difference in results of tests of samples taken from two locations in the concrete batch (2)
Mass per unit volume (kg/m^3) calculated to an air-free basis (9 of SLS 1144 : Part 2 : 1996)	16
Air content, volume % of concrete (9 of SLS 1144 : Part 2 : 1996)	1.0
Slump mm (4 of SLS 1144 : Part 2: 1996) If average slump is up to 100 mm If average slump is more than 100 mm up to 150 mm If average slump is more than 150 mm	 25 38 50
Coarse aggregate content, portion by weight of each sample retained on 4.75 mm sieve, expressed as per cent (9 of SLS 1144 : Part 2 : 1996)	6.0
Unit mass of air-free mortar based on average for all comparative samples tested, expressed as per cent (9 of SLS 1144 : Part 2 : 1996)	1.6
Average compressive strength at 7 days for each sample, based on average strength of all comparative test specimens expressed as per cent (11 of SLS 1144 : Part 2 : 1995)	7.5

8.2.7 Mixers and agitators shall be regularly cleaned, examined and maintained, to prevent build-up of hardened concrete in the mixing chamber and excessive wear of the mixing mechanism.

9 PRODUCTION AND DELIVERY

9.1 General

Ready mixed concrete shall be mixed and delivered to the point designated by the purchaser by means of one of the following combinations of operations:-

Central-mixed concrete (see 4.1);
Shrink-mixed concrete (see 4.3); and
Truck-mixed concrete (see 4.2).

Mixers and agitators shall be operated within the limits of capacity and speed of rotation designated by the manufacturer of the equipment.

The quantity of each ingredient in a batch shall be measured and controlled within the tolerance given for each ingredient in 7.6. In addition where the ratio of total water to cement ratio (W/C) has been specified, the moisture content of the aggregate shall be measured within the tolerance of $\pm$ 1 per cent of the aggregate mass and, where appropriate, adjustment to the quantity of added water made to maintain the ratio within $\pm$ 0.05 of the specified water-cement ratio.

Mixer shall be completely discharged before charging with a new batch.

9.2 Central-mixed concrete

In the case of central-mixed concrete the mixing time shall be counted from the time all the solid materials are in the drum. The sequence and timing of the introduction of ingredients, including admixtures and additives, shall be such as to realize the required properties of the concrete.

Where no mixer performance tests are made, the acceptable mixing time for mixers having capacities of 1 m^3 or less shall be not less than 1 min. For mixers of greater capacity, this minimum shall be increased 20 s for each cubic metre or fraction thereof of additional capacity.

Where mixer performance tests have been made on given concrete mixtures in accordance with the testing programme set forth in 9.3, and the mixers have been charged to their rated capacity, the acceptable mixing time may be reduced for those particular circumstances to a point at which satisfactory mixing defined in 9.3 shall have been accomplished.

9.3 Uniformity tests for stationary mixers

Samples of concrete shall be obtained immediately after arbitrarily designated mixing times in accordance with one of the following procedures:-

a) **Procedure 1**
The mixer shall be stopped, and the required samples removed by any suitable means from the concrete at approximately equal distances from the front and back of the drum; or

b) **Procedure 2**
As the mixer is being emptied, individual samples shall be taken after discharge of approximately 15 per cent and 85 per cent of the load. Any appropriate method of sampling may be used, provided the samples are representative of widely separated portions, but not the very ends, of the batch.

NOTE

(see Note under 8.2.4)

The samples of concrete shall be tested in accordance with 4, 9 and 11 of SLS 1144: Part 2 : 1996, and differences in test results for the two samples shall not exceed those given in Table 9. Mixer performance tests shall be repeated whenever the appearance of the concrete or the coarse aggregate content of samples selected as outlined in this section indicates that adequate mixing has not been accomplished.

9.4 Shrink-mixed concrete

In this type of concrete, stationary mixer is used initially for partially mixing of the ingredients where the time of partial mixing shall be the minimum required to intermingle the ingredients. After transfer to a truck mixer the amount of mixing at the designated mixing speed will be that necessary to meet the requirements for uniformity of concrete in Table 9. Tests to confirm such perfromance shall be made in accordance with 9.3. Additional turning of the mixer, if any, shall be at a designated agitating speed.

9.5 Truck-mixed concrete

The concrete is entirely mixed by the truck mixer. When revolved 70 to 100 revolutions with the speed specified by the mixing manufacturer, after all materials (including water) have been loaded in the truck mixer, the uniformity of concrete as specified in Table 9 shall be obtained. Concrete uniformity tests may be made in accordance with 9.6 and if requirements for uniformity of concrete indicated in Table 9 are not met with 100 revolutions of mixing, after all ingredients including water, are in the drum, that mixer shall not be used until the condition is corrected, except as provided in 8.2.5. When satisfactory performance is found in one truck mixer, the performance of mixers of substantially the same design and condition of blade may be regarded as satisfactory. Additional revolutions of the mixer beyond the number found to produce the required uniformity of concrete shall be at a designated agitating speed.

9.6 Uniformity tests for truck-mixers

The concrete shall be discharged at the normal operating rate for the mixer being tested, with care being exercised not to obstruct or retard the discharge by an incompletely opened gate or seal. Separate samples, each consisting of approximately 0.1 m^3 (100 L) shall be taken after discharge of approximately 15 per cent and 85 per cent of the load (see Note in 9.3).

These samples shall be obtained within an elapsed time of not more than 15 min. The samples shall be secured in accordance with procedure 2 of 9.3, but shall be kept separate to represent specific points in the batch rather than combined to form a composite sample. Between samples, where necessary to maintain slump, the mixer may be turned in mixing direction at agitating speed. During sampling the receptacle shall receive the full discharge of the chute. Sufficient personnel must be available to perform the required tests promptly. Segregation during sampling and handling must be avoided. Each sample shall be remixed the minimum amount to ensure uniformity before specimens are moulded for a particular test.

9.7 Delivery

Concrete shall be transported from the mixer to the point of placing as rapidly as practicable by methods that will maintain the required workability and will prevent segregation, loss of any constituents or ingress of foreign matter or water. The concrete shall be deposited as close as practicable to its final position to avoid rehandling or moving the concrete horizontally by vibration.

When a truck mixer or truck agitator is used for transporting concrete that has been completely mixed in a stationary mixer, any turning during transportation shall be at the speed designated by the manufacturer of the equipment as agitating speed.

When a truck mixer or agitator is approved for mixing or delivery of concrete, no water from the truck water system or elsewhere shall be added after the initial introduction of mixing water for the batch except when on arrival at the job site, the slump of the concrete is less than that specified. Such additional water to bring the slump within required limits shall be injected into the mixer under such pressure and direction of flow that the requirements for uniformity specified in Table 9 are met. If a maximum water-cement ratio has been specified, the quantity of water added shall be such that the specified ratio is not exceeded.

The drum or blades shall be turned an additional 30 revolutions or more if necessary at mixing speed, until the uniformity of the concrete is within these limits. Water shall not be added to the batch at any later time. Discharge of the concrete shall be completed within 1 1/2h, or before the drum had revolved 300 revolution, or before proper placement and compaction of the concrete can no longer be accomplished, whichever comes first, after the introduction of mixing water to cement and aggregates or the introduction of the cement to the aggregates. These limitations may be waived by the purchaser if the concrete is of such slump after the 1 1/2 h time or 300 revolution limit has been reached that it can be placed, without the addition of water, to the batch. In hot weather, or under conditions contributing to quick stiffening of the concrete, a time less than 1 1/2h may be specified by the purchaser.

The producer shall deliver the ready-mixed concrete during hot weather at concrete temperatures as low as practicable but not greater than 40^{0}C or 5 ^{0}C above the prevailing shade temperature, subject to the approval of the purchaser.

10 INSPECTION AND RECORDS

10.1 Inspection

The producer shall afford the inspector of the purchaser all reasonable access, and assistance without charge, for making necessary checks of the production facilities and for securing necessary samples to determine if the concrete is being produced in accordance with this specification. All tests and inspection shall be so conducted as not to interfere unnecessarily with the producer and delivery of the concrete. The inspector shall also be given all reasonable access and assistance without charge, for procurement of samples of fresh concrete at the time of placement to determine conformance of it to this specification.

10.2 Records

10.2.1 *General*

The producer shall keep batch records of the quantities by mass of all the solid materials, of the total amount of water used in mixing and of the results of all tests. If required by the purchaser, the producer shall furnish certificates, at agreed intervals, giving this information. Cement test certificates shall be made available to the purchaser on request. Records shall also be kept of the date and time of any plant malfunction.

10.2.2 *Certificate of delivery*

The producer of concrete shall furnish to the purchaser with each batch of concrete before unloading at the site, a certification of delivery (see Appendix C) on which is printed, stamped or written, information concerning said concrete as follows:

a) Name of ready-mixed batching plant;
b) Serial number of certificate;
c) Date;
d) Truck number;
e) Name of purchaser;
f) Name and location of the delivery site;
g) Grade or mix description of concrete;
h) Minimum or maximum cement content, if specified;
i) Specified workability;
j) Quantity of concrete in cubic metres;
k) Time of loading or of first mixing of cement and aggregates; and
l) Signature or initials of ready-mixed concrete producer.

Space should be provided for any additional items that have been specified and for the following to be completed on site:

i) Arrival and departure times of the truck;
ii) Time of completion of discharges; and
iii) Any other materials added on site and extra water added at the request of the purchaser of the concrete, or his representative, and his signature.

Additional information for certification purposes as designated by the purchaser and required by the job specification shall be furnished when requested. Such information may include:

a) Reading of revolution counter at the first addition of water;
b) Type and brand, and amount of cement;
c) Type and brand, and amount of admixtures;
d) Information necessary to calculate the total mixing water added by the producer. Total mixing water includes free water on the aggregates, water, and ice batched at the plant, and water added by the truck operator from the mixer tank;
e) Maximum size of aggregate;
f) Weights of fine and coarse aggregate; and
g) Ingredients certified as being previously approved.

11. SAMPLING, TESTING AND COMPLIANCE

11.1 General

All sampling and testing of the constituent materials shall be carried out in accordance with the standards specified in 7.1,7.2,7.3, and 7.4.

Concrete shall be sampled in the plastic state and tested for the specified quality parameters for compliance with this specification.

The point and time of sampling shall be at discharge from producer's delivery vehicle or from mixer when delivered into the purchaser's vehicle.

The rate of sampling adopted by the purchaser should be notified to the producer by quoting from Table 10 the average quantity of concrete, either in cubic metres or as the number of batches which ever represents the lesser volume, from which a representative sample shall be taken from randomly selected batch. At least one sample should be taken of each grade of concrete on each day that concrete is placed.

The concrete sample obtained shall be sufficient to conduct all the relevant tests specified in 11.2 or 11.3. If, in the case of prescribed mix concrete, the mix proportions have to be determined by analysis, place a suitable portion of the sample in a clean air-tight container and seal the container within 5 min of sampling.

The quantity of concrete represented by a group of four consecutive test samples shall include the batches from which the first and last samples were taken together with all intervening batches. Similarly, the first two or three samples shall be taken as representing all the intervening batches.

In the case of one sample, the particular batch from which the sample was taken shall be at risk.

TABLE 10 - Recommended minimum rates of sampling

Average rate of sampling: one sample per	Example of structures to which applicable
10 m^3 or 10 batches	Masts, columns, cantilevers
20 m^3 or 20 batches	Beams, slabs, bridge decks, walls
50 m^3 or 50 batches	Solid rafts, breakwaters, foundations

11.2 Designed Mixes

The following parameters shall satisfy the compliance requirements specified in **11.4**:-

a) Slump (see 4 of SLS 1144 : Part 2 : 1996)
b) Compressive strength (see 11 of SLS 1144 : Part 2 : 1996)
c) Uniformity of concrete(see 4, 9 & 11 of SLS 1144 : Part 2 : 1996)
d) Chloride content (If sea sand is used)
(see 5 of SLS 1144: Part 2 : 1995)

If the purchaser has specified the following parameters in his order, they shall also satisfy the respective compliance requirement specified, in **11.4**:-

i). Nominal maximum size of aggregate (see 7.2.1);
ii). Temperature (see 11.4.6);
iii). Constituent materials (see 7); and
iv). Water-cement ratio.

11.3 Prescribed Mixes

The following parameters shall satisfy the compliance requirements specified in **11.4**:-

a) Slump (see 4 of SLS 1144:Part 2:1996)
b) Mix proportions (see 10 of SLS 1144:Part 2:1996)
c) Uniformity of concrete
(see 4, 9, and 11 of SLS 1144:Part 2 : 1996);and
d) Choloride content (If sea sand is used)
(see 5 of SLS 1144 : Part 2 : 1996)
e) Maximum free water cement ratio (see 10 of SLS 1144:Part 2:1996).

If the purchaser has specified the following parameters in his order, they shall also satisfy the respective compliance requirements specified in **11.4**:-

i). Nominal maximum size of aggregate (see 7.2.1);
ii). Temperature (see 11.4.6);
iii).Constituent materials (see 7); and
iv). Minimum or maximum cement content
(see 10 of SLS 1144 : Part 2 : 1996)

11.4 Tests

11.4.1 *Compressive strength*

A sample shall be taken from a randomly selected batch of concrete by taking a number of increments in accordance with 11 of SLS 1144 : Part 2 1996.
The sample shall be taken as in **11.1**.

Three test specimens shall be prepared for compliance and all the specimens shall be cured as follows:-

a) for 28 days;
b) by any other regime of curing agreed between the producer and the purchaser (eg. 7 days normal curing or accelerated curing at an elevated temperature) that is capable of predicting the strength of 28 days.

To assess compliance as regards compressive strength, the first result alone cannot be used to judge compliance with the specified characateristic strength.

Compliance with the characteristic strength is based on groups of four consecutive test results. Compliance with the specified characteristic strength may be assumed if the average strength determined from any group of four consecutive test results and if each individual test result complies with the appropriate limits in columns A and B of Table 11 respectively.

When there are less than four results, i.e. at the start of a job or on small jobs, the average of the first 2 or first 3 results, and the individual results should comply with the appropriate limits in columns A and B of Table 11 respectively.

For a test result, the difference between the strength of two specimens prepared from the same sample shall not exceed 5 N/mm^2.

TABLE 11 - Compressive Strength Compliance Requirements

Specified Grade	Test Results	A: Average of first 2 of first 3, or of 4 consecutive test results exceeds the spcified characteristic strength by at least	Specified Grade	Test Results	B: Any individual test result is not less than the specified characteristic strength minus
C 20 and above	first 2 first 3	1N/mm^2 2 N/mm^2	C 30 and above	first 2 first 3	3 N/mm^2 3 N/mm^2
	consecutive 4	3 N/mm^2		consecutive 4	3 N/mm^2
Below C 20	first 2 first 3	0 N/mm^2 1 N/mm^2	Below C 30	first 2 first 3	2 N/mm^2 2 N/mm^2
	consecutive 4	2 N/mm^2		consecutive 4	2 N/mm^2

11.4.2 *Uniformity of concrete:*

Samples shall be taken in accordance with 9.3 or 9.6 and tested in accordance with 4.9, and 11 of SLS 1144 : Part 2 : 1996.

For the concrete to comply with this standard, the weight per cubic metre, air content, slump, coarse aggregate content, unit weight of air-free mortar and compressive strength shall conform with the requirements of Table 9.

11.4.3 *Slump*

A sample shall be taken after allowing a discharge of approximately 0.3 m^3. The sample shall be approximately 20 kg in mass and shall be collected from the moving stream in a bucket or other suitable container, taking care to obtain a full cross section of the discharge. The sample shall be remixed in a suitable tray, wheelbarrow or other wide shallow container, subdivided into two specimens and each specimen shall be tested for slump in accordance with 4 of SLS 1144:Part 2 : 1996. The average of the two slumps shall be the slump for compliance purposes. The tests shall be completed within 15 minutes of the time of receipt of the ready-mixed concrete at the site.

For concrete to comply with this standard, the slump (average of two tests) shall not differ from the specified value by ± 10 mm for a specified slump of 75 mm or less and ± 25 mm when the specified slump is greater than 75 mm.

11.4.4 *Chloride content*

The chloride ion concentration in water of a freshly mixed concrete sample shall be determined in accordance with 5 of SLS 1144 : Part 2 : 1996.

For concrete to comply with this standard it shall conform to requirements of Table 12.

TABLE 12 - Limits of chloride content of concrete.

Type or use of concrete	Maximum total percentage of chloride ion by mass of cement
Prestressed concrete Heat-cured concrete containing embedded metal	0.10
Concrete containing embedded metal made with cement complying with BS 4027	0.20
Concrete containing embedded metal and made with cement complying with SLS 107 or BS 1370	0.40
Other concrete	No limit

11.4.5 *Mix proportions*

This parameter can be obtained by observation of the batching, examination of the autographic record of the batch weights, or by tests on fresh concrete in accordance with 10 of SLS 1144:Part 2 : 1996.

For concrete to comply with this standard:-

a) Cement content shall not be less than 95 per cent of that specified ;

b). The ratio of coarse to fine aggregates shall neither exceed nor fall below the ratio specified by the purchaser by more than 10 per cent; and

c). The water/cement ratio shall be within $\pm$ 5 percent of the specified value.

11.4.6 *Temperature*

The temperature of the fresh concrete shall be measured in one of the following ways:-

a) Within 2 min of taking the sample at delivery insert an immersion thermometer having a range of -5 ^{0}C to + 110 ^{0}C, graduated at each 1^{0}C. When steady conditions have been maintained for 1 min record the temperature to the nearest 1 ^{0}C; or

b) Use an alternative form of temperature measurement which provides the same accuracy as given in item (a).

The measured concrete temperature shall not exceed any specified maximum value or fall below any specified minimum value.

11.5 Cost of testing

The cost of the tests carried out in accordance with the requirements of this specification shall be borne as follows:

a). By the producer if the results show that the concrete does not comply with the requirements of this standard; and
b). By the purchaser if the results show that the concrete complies with the requirements of this standard.

12. NON - COMPLIANCE OF THE REQUIREMENTS

The action to be taken in respect of the concrete which is represented by test results that fail to meet the requirements of the specification prepared in accordance with this standard should be determined by the purchaser. This may range from qualified acceptance in less severe cases to rejection and removal in the most severe cases. In determining the action to be taken, due regard should be given to the technical consequences of the kind and degree of non-compliance and to the economic consequences of alternative remedial measures, either replacing the substandard concrete or ensuring the integrity of any work in which the concrete has been placed.

In estimating the quality of the substandard concrete indicated by the valid test results and in determining the action to be taken, the following should be established, wherever possible ;

a) the mix proportions actually used in the concrete under investigation which may affect durability;

b) the section of the work represented by the test results;and

c) the possible influence of any reduction in concrete quality on the strength and durability of the work.

In order to assess (c) above, concrete core testing and/or non-destructive testing can be carried out to estimate the in-situ strength of the concrete that has not complied with this standard.

In the event that concrete fails to comply with the specifications prepared in accordance with this standard, the producer of the ready-mixed concrete and the purchaser shall confer to determine whether agreement can be reached as to what adjustment, if any, shall be made. If an agreement on a mutually satisfactory adjustment cannot be reached by the producer and the purchaser, a decision shall be made by a panel of three qualified engineers, one of whom shall be designated by the purchaser, one by the producer, and the third chosen by these two members of the panel. The question of responsibility for the cost of such arbitration shall be determined by the panel. Its decision shall be binding, except as modified by a court decision. As an alternative, the purchaser and the producer may agree to refer the dispute to one arbitrator nominated by the Institution of Engineers of Sri Lanka.

13. PRECAUTIONARY MEASURES

When cement is mixed with water, alkali is released. Take precautions to avoid dry cement entering the eyes, mouth and nose when mixing cement or concrete by wearing suitable protective clothing. If cement or concrete enters the eye, immediately wash it out thoroughly with clean water and seek medical treatment without delay. Wash wet concrete off the skin immediately.

Many admixtures are highly active chemicals and to ensure safe usage, supervision and quality control should be of a higher standard than for normal concrete work.

APPENDIX A
GUIDANCE ON SPECIFICATION OF CONCRETE

A.1 GENERAL

The following clauses are given as general guidance in the specification of concrete. Reference should be made to the appropriate literature for more detailed information.

A.2 DESIGNED OR PRESCRIBED MIX

In general, a designed mix will be cheaper than a prescribed mix. However, if both are equally priced, prescribed mix will be more beneficial as it consumes more cement and because compliance can be checked more easily and effectively by observing operations at the batching plant. Prescribed mixes may also be specified where the scale of work or economy does not justify the application of mix design procedures or to enable work to start where there is insufficient time for the collection of data to support mix design proposals. In general, producers have designed mixes for most grades of concrete so that purchaser may not be burdened with the proportioning of designed concrete mixes.

The required strength grade can be selected from Table 1 depending on the application. Use of a strength greater than the minimum required often leads to a higher cost, but prestressed concrete is an exception. Also hand compaction leads to higher cost as the cost increases with the higher slump required for hand compaction.

It is implicit in the standard that the plastic concrete supplied by the producer should have at least the potential to attain the specified hardened state properties, and can achieve these properties within the specified time after the plastic concrete has been accepted by the purchaser.

Specifications in this standard are intended to demonstrate whether or not the producer has met this responsibility, by requiring representative test specimens to be made, cured and tested in the hardened state, under standardized laboratory conditions.

Whether the concrete eventually develops its specified hardened state properties on site, is directly affected by virtually everything a purchaser does after receiving the concrete in the plastic state. They are affected by the handling, placing and compacting techniques employed, the methods and duration of curing used and the method, sequence and timing of any formwork stripping involved. All of these factors are outside the control of the producer, who therefore cannot realistically be held responsible for the hardened state properties actually achieved on site.

Assessment for compliance of concrete with in-situ hardened properties is therefore outside the scope of this standard.

In the case of dispute, hardened state properties may be used to advantage by the producer.

A.3 SLUMP OF CONCRETE

The requirements of concrete in the fresh or plastic state, particularly its workability, should take account of the conditions and procedures to be used at the site. The properties of the fresh concrete may be modified by the use of admixtures.

In specifying the properties of fresh concrete to the producer, the purchaser of the fresh concrete should take account of the possibility of changes in the properties during transport under the purchaser's control up to the point of delivery into the construction.

A value of slump should be selected for the ranges given in Table 8, paying attention to the usage, allowable tolerance and proposed method of placement and compaction.

A.4 QUANTITY OF CONCRETE AND RATE OF DELIVERY

Quantity of concrete required should be worked out from the Bill of Quantities and the drawings. Rate of delivery should be decided based on facilities for concrete placement and compaction at site. Local suppliers can execute orders ranging from 0.5 m^3 to 3000 m^3 and can achieve supply rates up to 60 m^3/hour.

A.5 NOMINAL MAXIMUM SIZE OF AGGREGATE

Highest possible size complying with 6.6 should be selected.

A.6 CEMENT FOR PUMPING

In general, pumping low strength concretes will require a greater additional cost as regards materials. Local producers can execute very small orders such as 5 m^3 as well as large orders involving placement at the rate of at 400 m^3 per day.

A.7 TYPE OF CEMENT

Cement should be selected considering the application and noting that ordinary Portland cement is the cheapest.

A.8 TEMPERATURE

Temperature is not an important parameter in local conditions, except in large concrete pours. Low temperature concrete is expensive, extends stiffening time leading to increased formwork pressures and delays in finishing and reduces rate of concrete strength development leading to delays in subsequent contruction operations like striking of formwork. Hence low temperature concrete should be used only when absolutely necessary.

APPENDIX B
FORM FOR SPECIFYING DESIGNED MIXES OR PRESCRIBED MIXES

Section 1 : Essential items

Type of mix			Designed/ Prescribed
Permitted type(s) of cement (ring those permitted)			SLS 107 BS 1370 BS 4027
Permitted type(s) of aggregate (ring those permitted)	Coarse :		BS 882
	Fine :		BS 882
Nominal maximum size of aggregate (ring one) 40 mm 20 mm 14 mm 10 mm			
CONCRETE		GRADE (ring one)	
Designed mix		Prescribed mix with volume batching	Prescribed mix with weigh batching
D 7 D 40 D 10 D 50 D 15 D 60 D 20 D 25 D 30		P 7 V P 10 V P 15 V P 20 V P 25 V P 30 V	P 7 W P 10 W P 15 W P 20 W P 25 W P 30 W
Minimum cement content .... kg/m³ RATE OF SAMPLING Number of cubic metres per sample .... Number of specimens per sample			
Mix proportions (prescribed mixes only)			
Cement ..... kg Coarse aggregate ..... kg Fine aggregate ..... kg		kg m³ m³	....m³ ....m³ ....m³

Section : Optional items

Workability Slump .... mm		Maximum free-water/cement ratio Maximum cement content....kg/m^3
Special requirements for aggregates	Coarse : Fine :	
Admixtures	Specified : Prohibited:	Quantity :
Air content .... % by volume	Temperature of fresh concrete ..... ^{0}C maximum ..... ^{0}C minimum	
Specification of trial mixes		
Details of test procedures		
Method of assessment procedures	As SLS...	Clauses
Other requirements		

APPENDIX C

DELIVERY NOTE FOR READY - MIXED CONCRETE

<table>
<tr><td colspan="7">Delivery Note for Ready-mixed Concrete
No .
Month day Year
Mr.
Name of producer and plant</td></tr>
<tr><td colspan="2">Place of delivery</td><td colspan="5"></td></tr>
<tr><td colspan="2">Transport vehicle number</td><td colspan="5"></td></tr>
<tr><td rowspan="2">Time of delivery</td><td>Departure</td><td colspan="5">(To the minute)</td></tr>
<tr><td>Arrival</td><td colspan="5">(To the minute)</td></tr>
<tr><td colspan="2">Delivery volume</td><td colspan="2">m³</td><td>Total</td><td colspan="2">m³</td></tr>
<tr><td rowspan="2">Designation</td><td>Type of concrete</td><td>Nominal strength</td><td>Slump</td><td colspan="2">Maximum size of coarse aggregate</td><td>Type of cement</td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td colspan="2">Receiving officer's signature</td><td></td><td colspan="2">Producer's signature</td><td colspan="2"></td></tr>
<tr><td>Remarks</td><td colspan="6"></td></tr>
</table>

APPENDIX D
TECHNICAL INFORMATION OF THE READY-MIXED CONCRETE

Technical Information of Ready-mixed Concrete

No. ----------

Month ---------- day---------- Year ----------

Mr. ----------

Name of producer and plant ----------

	Name of person in change of batch		
Name of work			
Location			
Appointed time of delivery			
Applicable period of this batch	a.m/p.m		
Placing point of concrete	a.m./p.m		
Designing conditions of this batch			
Designation	Grade of concrete	Nominal strength	Slump
Designated items	Air content	%	
	Material age guaranteeing nominal strength	day (s)	
	Upper limit value of water-cement ratio		
	Upper limit value of unit water content	kg/m^3	
	Increase in slump value after plasticization	mm	
	Temperature of concrete/Highest ^0C	lowest ^0C	
Materials used			
Cement	Name of Producer	Type	
Fine aggregates	Type of fine aggregate		
	Maximum size		
	Chloride content (if sea sand)		
Coarse aggregates	Type of coarse aggregate		
	Maximum size		
Chemical Admixture Material 1	Name of product	Type	Retarder/Plasticizer/.....
Admixture Material 2	Name of product	Type	Retarder/Plasticizer/...

Proportion Table (kg/m^3)

Cement	Water	Fine Aggregates	Coarse Aggregates	Admixture Material 1	Admixture Material 2

Water-cement ratio		Percentage of fine aggregates in aggregates	% (by weight/volume)
Remarks			

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