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香港中區立法會道一號
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立法會秘書處
交通事務委員會秘書
劉素儀女士

劉女士：

立法會交通事務委員會
中環及灣仔繞道的工程質素及相關問題

謝謝你於 2019 年 2 月 19 日來信轉介陳淑莊議員於 2019 年 1 月 11 日的信函。就陳議員有關中環及灣仔繞道（“繞道”）混凝土質量事宜的查詢，本局知悉陳議員曾於 2019 年 1 月 9 日就相同事宜致函路政署（見附件一）。路政署已於 2019 年 1 月 21 日作出詳細回覆（見附件二），確認有關混凝土溫度和表面及核心溫差過高的現象不會影響混凝土強度或隧道結構，並提供有關獨立專家調查研究報告，交代研究內容及闡述背後的理據。

正如路政署在其覆函中所述，政府推展運輸基建項目時，一向以工程品質及施工安全為首要考慮。工程顧問公司駐工地人員會嚴謹按照現有的管理機制，密切監督承建商的工作表現，並在發現有工序未達合約要求時，指示承建商落實有效的改善措施，從而確保工程質量符合相關標準。

運輸及房屋局局長

(陳凱庭  代行)

2019 年 3 月 14 日

副本抄送：

路政署署長 (經辦人：黎國輝先生) (傳真：2714 5289)



立法會 Legislative Council

陳淑莊議員 Hon CHAN Tanya



九龍何文田忠孝街八十八號
何文田政府合署五樓
路政署總辦事處
路政署署長
陳派明先生, JP



陳署長：

有關中環灣仔繞道事宜

中環灣仔繞道日前被傳媒揭發部分石屎在澆注和凝固時的溫度和溫差不合格。鑑於事件涉及公眾安全問題，就此，本人現特致函 閣下提出下列查詢：

- (一)就報導提及，政府當局指中國建築已委託專家調查，認為不會減弱石屎強度和隧道結構。請 貴署說明為何政府當局未有自行委託第三方進行調查及採納上述報告的原因；
- (二)除報導提及於 2013 至 2014 年發生上述事故外，整個中環灣仔繞道工程期間是否仍有同類型狀況發生；若有，請提供相關詳情；
- (三)請說明為何承建商多次未有遵從當局定下的相關質量要求， 貴署卻仍然接收一個未符合施工質量的工程，及；
- (四)就承建商多次未有遵從當局定下的質量要求， 貴署是否曾向有關承建商作出任何懲處；若有，有關懲處為何；若否，原因為何？

鑑於事件涉及重大公眾安全問題，亦直接影響公眾對中環灣仔繞道結構安全信心，故本人要求 貴署公開承建商委託專家所作的調查報告。盼望 閣下能盡快回應本人的查詢，並準確地提供所有相關的資料。如有任何垂詢，煩請電 2521 6106 與本人聯絡。

DHy	DD	AD/T	AD/D	TS	SE/P	SE/CA1	SE/CA2	SE/SEA	SE/PR	SGE 1	SGE 2	SE/QM	SE/T&C	SE/BIM	DS	STA
B.U.					C.C.					Ref. To						

立法會議員
陳淑莊 謹啟

二零一九年一月九日

[]

郵遞急件



**HIGHWAYS DEPARTMENT
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陳淑莊議員

敬啟者：

有關中環及灣仔繞道事宜

謝謝你在 2019 年 1 月 9 日致本署署長的函件，詢問有關中環及灣仔繞道（“繞道”）混凝土質量的事宜，本署現就閣下的關注有以下回覆：

一般來說，控制混凝土的溫度和其表面及核心的溫差的主要目的是為了避免混凝土由於過度收縮引起的熱裂紋。因此，關於繞道的混凝土護養，按照合約一般要求，混凝土在護養過程中溫度不應高於 70 度，而混凝土表面及核心的溫差不應高於 24 度，以有助防止熱裂紋的產生。但根據檢測結果，這些護養溫度上限及溫差控制的要求，與混凝土的最終強度和質量，並無絕對的直接關係。若然混凝土養護工序未能符合上述溫度控制的要求，有可能會因影響水泥的水化過程（即水泥與水經過化學反應從而硬化並續步增強混凝土的強度）而減弱混凝土的長遠強度，但影響程度將因應其他因素例如混凝土的不同設計而有所差異。溫差過大則可能會導致混凝土出現熱裂紋而影響混凝土的質量。另一方面，合約同時要求在混凝土的設計中，必須加入不少於 25% 的粉煤灰以增強長遠強度，該作用剛好抵消了或因未能符合護養溫度及溫差標準而可能引起的強度及質量問題。

翻查記錄，本署駐工地人員在 2013 年至 2014 年間，分別發現承建商在混凝土養護工序中的溫度及溫差上未能符合合約的要求。為了保證混凝土的質量達標，本署駐工地人員已要求承建商對相關隧道段的混凝土質量進行檢測及提高護養效果。據工地記錄，有關混凝土在完成養護工序後，並沒有出現特別因溫差影響引起的熱裂紋問題。



ISO 9001:2015
證書編號: CC 1881

ISO 14001:2015
證書編號: CC 2634

其後，承建商就溫度及溫差不達合約要求事件更委託了獨立專家進行調查研究。調查研究結果要點如下：

- (一) 調查研究檢視了有關混凝土及鋼筋設計和混凝土試磚強度測試報告，並且該混凝土試磚強度測試報告證實了混凝土強度遠高於設計要求；
- (二) 獨立專家根據英國歐盟標準 BS EN 1992 混凝土結構設計和 CIRIA C660 “混凝土早期熱裂紋控制” 報告，按相關錄得的混凝土強度及最高溫差，推算出混凝土澆灌後第三天的估計最大裂紋寬度僅為 0.03 毫米，遠低於路政署的「道路及鐵路結構設計手冊」的指引容許之上限要求：0.25 毫米。因此，裂紋符合上述設計手冊的標準；
- (三) 根據 CIRIA C660 附錄 A9 關於“峰值溫度對早期混凝土強度的影響”，報告指出如果在早期階段混凝土迅速加熱，混凝土的長期性能可能會受到不利影響；但如果在混凝土成份中加入粉煤灰，將會有效減低在早期熱循環中，高溫對該混凝土所產生的不利影響，從而保留混凝土的相應強度。根據記錄，承建商在混凝土的設計上，完全按照合約要求加入了不少於 25% 的粉煤灰。獨立專家認為此含有粉煤灰的混凝土設計，有效地抵消了因護養溫度過高而有可能產生的影響。因此，混凝土的長遠強度及質量並未受影響；
- (四) 獨立專家檢閱了有關混凝土完成養護工序後觀察到的輕度裂紋報告，在該段有關約 750 米長的隧道內發現有輕度裂紋散布在不同位置、長度不同但寬度不超過 0.25 毫米。他認為上述裂紋沒有特定的圖案，並且長度和散布方向不同，極不可能是由於上述護養溫度及溫差不達合約要求而導致的熱裂紋，加上這些裂紋被確認遠低於路政署的「道路及鐵路結構設計手冊」的指引容許之上限要求：0.25 毫米。因此，證明裂紋符合上述設計手冊的標準；
- (五) 基於以上考慮，獨立專家確立了雖然在護養期間有關部分溫度及溫差不達合約的要求，但不會減弱混凝土的強度，同時亦不會對隧道的結構、保養及耐用程度構成影響。

本署駐工地人員綜合檢視個案詳情及研究該專家的意見後，有如下的看法：

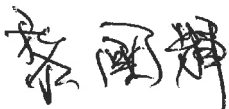
- (六) 根據混凝土強度壓力測試報告，這些混凝土試磚的強度均大幅度高於合約要求。這足以抵消上述可能發生的不利影響，令到有關混凝土的長期強度不會減弱，因此是可以接受的；
- (七) 就該養護工序是否導致混凝土表面產生裂紋，本署駐工地人員同意上述獨立專家的意見。他們認為英國歐盟標準 BS EN 1992 混凝土結構設計是國際受認可的設計規格標準，而 CIRIA 是一個獨立的建築業研究和信息協會。該協會的 CIRIA C660 報告內容更被用作制定英國混凝土早期熱裂紋設計的國家標準基礎。因此基於上述標準和報告的研究而推算出的最大裂紋是可以接受的。他們認為裂紋寬度大幅小於 0.25 毫米，已滿足 0.25 毫米設計要求，並相信這些裂紋是因為濕度變化而導致的收縮裂紋，不屬於溫差影響引起的熱裂紋。這些收縮裂紋已在混凝土鋪設防水保護層前，以環氧樹脂填料完成修補；
- (八) 綜合上面所述，本署駐工地人員審閱了該獨立專家的報告並與該獨立專家意見一致。有關繞道部分在養護期間，雖曾出現溫度及溫差檢測未能符合合約的一般要求，但不會因此而減弱混凝土的強度，同時亦不會對隧道的結構，保養及耐用程度構成影響。

考慮到上述調查研究報告已經由獨立專家進行，而駐工地人員也認同報告的結論，本署研究後認為沒有需要另外再委託獨立專家進行同樣的調查。另外，該調查研究報告屬於承建商擁有，我們得到他們的允許隨函夾附有關的研究報告供參考。

在上文中，我們已經扼要地交代了該調查研究的結果及獨立專家的專業意見。因上述事件，本署駐工地人員已屢次去信和在每月進度會議中告誡承建商有關不合乎合約要求的混凝土養護工作、督促他們需嚴格遵守合約要求，並按合約條款要求承建商作出相關改善措施。就此，承建商提交及落實了關於混凝土澆灌及養護流程的改善措施，例如：改善冷卻管的設計，並收緊溫度的控制，確保質量符合相關標準。整個繞道工程沒有出現混凝土不符合質量的情況。

工程質量及施工安全為本署首要關注。本署駐工地人員一貫採用嚴緊的管理機制，以及監察各個工序的流程，密切監督承建商以確保工程的設計及建造均符合相關要求，確保工程質量。綜上所述，本署已就閣下關注事宜作詳細說明。如閣下尚有任何查詢，請與我們聯絡。

路政署主要工程管理處 總工程師 4

(黎國輝 )

附件：獨立專家調查研究報告

副本送：

路政署總辦事處公共關係組(經辦人：楊漢輝先生)

傳真：2187 2243

二零一九年一月廿一日



1.0 INTRODUCTION

- 1.1 I, Dr Lam Siu-shu Eddie, am instructed by China State Construction Engineering (Hong Kong) Limited to express my expert opinion on matters related to concrete temperature under Contract No HY/2009/15, Central-Wan Chai Bypass – Tunnel (Causeway Bay Typhoon Shelter Section).
- 1.2 I, Dr Lam Siu-shu Eddie, am an Associate Professor of The Hong Kong Polytechnic University, Barrister and Mediator.
- 1.3 I am Fellow of the Hong Kong Institution of Engineers, Fellow and Council Member of the Institution of Structural Engineers, Member of the Institution of Mechanical Engineers, Registered Structural Engineering (Hong Kong) and Class-1 Registered Structural Engineering (PRC).
- 1.4 I was the Chairman of the HKIE Structural Division (2011-2012), the Chairman of Quality Building Award 2012, a chairman of Disciplinary Tribunal Panel of the Builders' Lifts and Tower Working Platforms (Safety) Ordinance, a chairman of the Construction Registration Committee for Registered General Building Contractors and for Specialist Contractors (Foundation), etc.
- 1.5 I was a member of Appeal Tribunal (Building), Town Planning Appeal Board Panel, Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers Committee, etc.
- 1.6 I have acted as an expert witness on disputes concerning building collapse, structural engineering, defects, workmanship, etc., and my expert opinion was accepted by the Court.



2.0 BACKGROUND

- 2.1 At the material time, concreting work with concrete temperatures recorded was carried out on the TPCWAE tunnel structure.
- 2.2 With reference to Particular Specification of the captioned at clause 16.46(2) (“the Clause”), temperature control for concrete requires (a) peak temperature not higher than 70C; and (b) maximum temperature differential not exceeding 24C.
- 2.3 Based on the measurements obtained from thermocouples installed in concrete, non-compliance with the Clause was reported at various locations including wall, base slab and roof slab.
- 2.4 The matter to address is whether the non-compliance with the Clause has adversely affected the structural performance and durability. To assess the effect of temperature to structural performance, crack width based on tensile strength and other properties of concrete, concrete cover, reinforcement detail, etc. is assessed.
- 2.5 The main concerns are on (a) the early strength (3 days) and (b) the effect of peak temperature on in-situ strength. CIRIA C660 on “Early-age thermal cracking in concrete” refers.



3.0 THE DATA

3.1 Annex A gives the mean compressive strength of test cubes at the age of or about 28 days in respect of the matter as per based on the test results on mean compressive strength of test cubes (Annex D: “20151201 TPCWAE Concrete cube summary.1.xlsx”).

a. Overall averaged compressive strength is 65.4 MPa.

b. Grade of concrete is $65.4 - 5 \text{ MPa} = 60.4 \text{ MPa}$ or C60.

3.2 Based on the temperature records as per enclosed in the tables exhibited in letter dated 4/6/2013 from AECOM, ref: CWB(HY/2009/15)/C40/340/15B010064 (Annex B) and additional information (in yellow) in the reports on temperature monitoring (Annex D: Roof slab T5 “CCWI013221.pdf”, Base slab C3-C and Roof slab T6 “CCWI013393.pdf”, Roof slab T1 and Base slab C3-B “CCWI013529.pdf”, Base slab B6 “CCWI013869.pdf”, Wall W12 “CCWI014037.pdf”, Wall W3, Wall W8A “CCWI04297.pdf” and Roof Slab T2 “CSF ref. No.: CCW/2002/CSF/WAE/42160”), temperatures as per recorded are summarised in Table 3.1.

Table 3.1 Measured temperatures non-compliance with the Clause

Type	Bay no	Thickness (mm)	Maximum T (C)	Maximum ΔT (C)
Wall	W9	1500	78	18
	W10	1500	78	21
	W5	1500	81	34
	W6	1500	80	37
	W1	1500	74	19
	W2	1500	73	16
	W7	1500	77	18
	W11	1500	78	31
	W15b	1500	77	24
	W12	1500	78.7	17.5
	W3	1500	68.7	28.4
W8A	1500	74.4	25.2	
Base slab	B1-1 & B2-1	2500	82	31
	B3-1 & B4-1	2500	82	28
	B1-2 & B2-2	2500	79	35
	B3-2 & B4-2	2500	84	33



	B5	2500	77	20
	C3-C	2500	74.9	17.0
	C3-B	2500	81.4	28.3
	B6	2500	74.3	23.5
Roof slab	T3	3000	84	27
	T4	3000	84	22
	T5	3000	83.8	27.8
	T1	3000	79.8	32.3
	T6	3000	79.9	20.3
	T2	3000	89.9	30.1
	Shaft A	3000	80.6	20.1

3.3 Reinforcement detail of the relevant wall, base slab and roof slab are compiled in Table 3.2 with the respective concrete cover given in Table 3.3.

Table 3.2 Reinforcement detail (staggered laps)

Description	Longitudinal reinforcements	Transverse reinforcements
External wall W01	T25@150 – 2 layers	T50@150 – 2 layers
External wall W03	T25@150 – 2 layers	T50@150 – 2 layers
Base slab	T40@150 – 2 layers	T50@150 – 2 layers
Roof slab	T40@150 – 2 layers	T50@150 – 2 layers

Table 3.3 Nominal cover

LOCATION	NOMINAL COVER (mm)
INTERNAL WALL	40
ROOF/BASE SLAB/CAST IN-SITU EXTERNAL WALL	
- EXTERNAL	40
- INTERNAL	55*

*Galvanized mesh D49 (2.5 mm diameter at 100 mm spacing both ways) should be provided to internal face of suspended cover of 20 mm to achieve a fire rating of 4 hours.



4.0 THE ANALYSIS AND CONCLUSIONS

Early strength

4.1 Crack widths at the age of 3 days of C60 concrete at measured temperature differentials are compared with that of C40 concrete at maximum temperature differentials (i.e. 24C) pursuant to the Clause. Computations are given in Annex C based on CIRIA C660, “Early-age thermal crack control in concrete”. N.B. The equivalence of C60 and C40 to CIRIA C660 are C50/60 and C30/37 respectively.

4.2 The following are assumed following the recommendation in CIRIA C660.

- a. Coefficient of thermal expansion of concrete/aggregate is based on design value for granite at 10 micro-strain/C, Table 4.4 of C660.
- b. Characteristic yield strength of reinforcements is 500 MPa.
- c. Internal restraint $R = 0.42$, Section 4.7.2 of C660.

4.3 The results are summarized in Table 4.1.

Table 4.1 Estimated crack width due to internal restraint

Type	T (mm)	Reinforcement	Cover (mm)	Concrete grade	ΔT (C)	Crack width (mm)
Wall	1500	T25@150 x 2	40	C40	24	0.01
				C60	37	0.03
Base slab	2500	T40@150 x 2	40	C40	24	0.01
				C60	35	0.02
Roof slab	3000	T40@150 x 2	40	C40	24	0.01
				C60	32.3	0.02

4.4 Pursuant to Structures Design Manual for Highways and Railways (3rd Edition) at



Table 21 (Annex E), design crack width is 0.25 mm for C40 (with nominal cover at 35 mm only). As shown in Table 4.1, crack width due to temperature effect is 0.03 mm at most. Thus, the requirement on design crack width is deemed to satisfy.

- 4.5 Further, autogenous healing takes place for young concrete, like in the present case at the age of 3 days. Autogenous healing is primarily due to the hydration of cement combined with the deposition of calcium carbonate from the cementitious material. The maximum crack width of which can undergo autogenous healing is commonly recognized to be 0.1 mm to 0.2 mm. It is generally believed that BS 8007:1987 “Code of practice for design of concrete structures for retaining aqueous liquids” and its successor BS EN 1992-3:2006 “Eurocode 2. Design of concrete structures. Liquid retaining and containing structures” have adopted the concept of autogenous healing to define the crack width limits.
- 4.6 All in all, the crack width caused by temperature effect at 0.03 mm at most will not affect the durability of the structure.

Effect of peak temperature

- 4.7 As quoted from CIRIA C600 at Annex A9, “*It is well recognized that if concrete is heated rapidly during the early period of hydration, the long term properties may be adversely affected*”; “*One commonly used value is 70C*”; and “*In particular the heat cycled 28-day strength for CEM I concrete was appreciably lower than that of standard cured cubes.*” However, the above does not apply to the present case.
- a. Fly ash (at a level of >20%) is used in the concrete mixes. This has the beneficial effect of enhancing the in-situ strength at 28 days instead of adversely affecting the early thermal cycle.
 - b. The above can be verified by examining the in-site strength as per estimated earlier by coring.
 - c. In respect of the (unlikely) risk of delayed ettringite formation (“DEF”), a



delayed form of sulphate attack in concrete with relatively high sulfate content and experienced high temperature at the earlier age, fly ash at level of > 20% is used. This prevents DEF-induced expansion in concrete when subjected to peak temperature up to 100C. In the present case, the peak temperatures are 81C to 89.9C and well below 100C.



5.0 CRACKS IN TPCWAE TUNNEL WALL

- 5.1 Various cracks were observed upon inspection by others on 5 November 2015, 12 November 2015 and 15 January 2016 as per reported in Annex F.
- 5.2 Upon perusal of the above-mentioned cracks from the reports especially locations and directions of propagation, I am of the opinion that the above-mentioned cracks have no specific patterns; that they vary in length and directions of propagation; and that they are highly unlikely caused by the non-compliance with the Clause.

A9 The effect of peak temperature on the *in situ* strength and durability of concrete

A9.1 Strength development

A9.1.1 Background data

It has been recognised for many years that if concrete is heated too rapidly during the early period of hydration, the long term properties may be adversely affected. This is demonstrated by the limits placed on the rate of heating for precast heat cured elements (Richardson, 2003). While it is difficult to control the rate of heat evolution *in situ*, the maximum peak temperature is commonly specified for massive sections and concretes likely to achieve a significant temperature rise during hydration. A commonly used value is 70 °C. One reason for this limit is to ensure that the *in situ* strength is not impaired significantly.

In a study of the influence of the natural heat cycle in very thick sections (Bamforth, 1980) significant changes in the rate of strength development of heat cycled concretes were observed. In particular the heat cycled 28-day strength for CEM I concrete was appreciably lower than that of standard cured cubes. Similar findings have been reported more recently by Barnett *et al* (2005), Sato *et al* (2001) and Sugiyama *et al* (2000). In the most extreme case, (Sato *et al*, 2001) the core strength at 56 days for concrete with a peak temperature of 70 °C was less than 50 per cent of cores removed from the same concrete with a peak temperature of 56 °C.

Sugiyama *et al* (2000) imposed a variety of temperature cycles on the concrete, with variation in the start time, the rate of temperature rise and fall and the peak temperature. The results, shown in Figure A9.1, were obtained for concrete subjected to a heat cycle that closely represented a natural early age heat cycle.

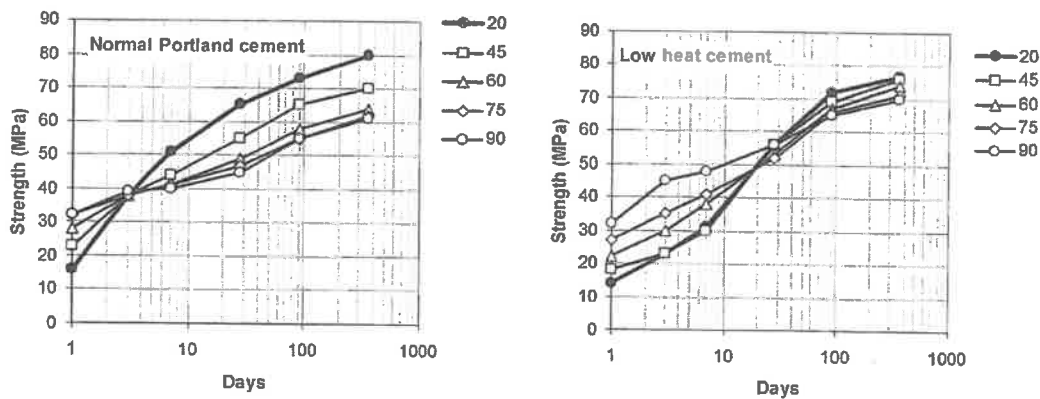


Figure A9.1 Strength development as affected by the peak temperature achieved during an early age heat cycle (Sugiyama *et al*, 2000)

It can be seen that for CEM I concrete, while the early temperature cycle resulted in acceleration of the strength development within the first few days, the subsequent rate of strength gain was reduced such that at 28 days, the heat cycled strength was up to 25 per cent below the strength of concrete cured at 20 °C. With low heat cement, however, the early benefit in strength development was still observed (during the initial 14 days) but without the long term strength development being impaired.

A9.1.2 The Concrete Society Study

In a comprehensive study of the *in situ* strength of concrete to establish the relationship between core and cube strength (Concrete Society, 2004) similar findings were reported. The testing was carried out to measure the *in situ* strength of a variety of concrete mixes cast into elements of differing geometry. The following factors were investigated

- concrete strength class - target strengths of 30MPa and 50MPa were used to represent low and medium strength concrete
- cement type – four cement types were used, CEM I, Portland limestone cement (LPC), 70 per cent CEM I/30 per cent fly ash and 50 per cent CEM I/50 per cent ggbs
- aggregate type – limestone and quartzite gravel
- element geometry – Concrete blocks (1.5 × 1.7 × 1.2m) insulated on all but one face, 300mm walls cast in plywood formwork and 200 mm thick slabs
- time of casting – winter and summer.

The early age temperature rise was measured in each of the specimens and cores were extracted for testing at 28, 42, 84 and 365 days. An example is shown in Figure A9.2 for the 30 MPa CEM I concrete using quartzite gravel aggregate cast in the summer into the different elements. The influence of the peak temperature on the rate of strength development is clear. In the section which achieved the highest peak temperature of about 60 °C, the core strength at 28 days was about 35 per cent lower than the cube strength. While these results were broadly in line with the findings of Bamforth (1980) and Sugiyama et al (2000) other researchers have reported less influence of the early heat cycle. Barrett *et al* (2005) reported a difference between heat cycled and standard cured cubes at 28 days of only 10 per cent. It is clear, however, that for CEM I cement concretes, the *in situ* strength may be adversely affected, and to a considerable extent, by permitting a high peak temperature.

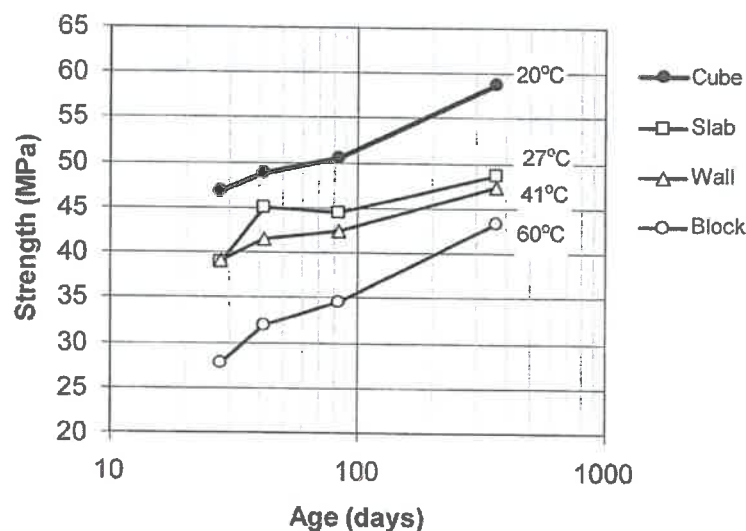


Figure A9.1 The strength development in elements of different size and achieving different peak temperatures (shown) during the early thermal cycle (Concrete Society, 2004)

Figure A9.3 shows the relationship between peak temperature T_p and the ratio of core/cube strength obtained from the Concrete Society study for the range of elements and concretes cast using CEM I concrete. This shows an approximately linear relationship between the peak temperature and the *in situ* strength expressed as a proportion of the 28-day cube strength.

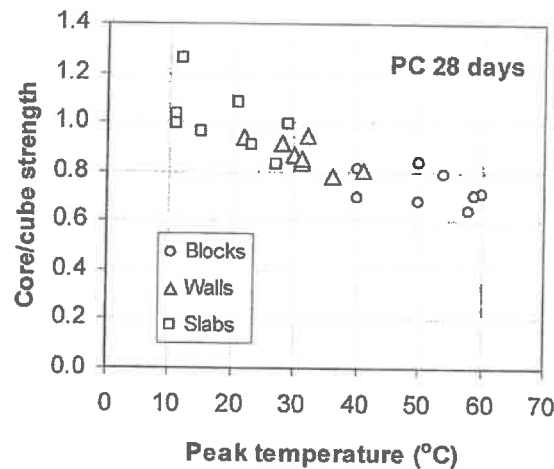


Figure A9.3 The effect of the peak early age temperature on the ratio of the core/cube strength at 28 days (Concrete Society, 2004)

In order to develop a better understanding of the way in which the peak temperature influences strength, the Concrete Society data have been analysed in more detail. Results are shown in Figure A9.4 (expressed as the ratio of the core strength achieved at 28, 42, 84 days and 1 year to the 28-day cube strength) for concretes using each of the four cement types. While there is some scatter to the results, clear trends are apparent. For example, the lower *in situ* strength achieved with higher peak temperature for CEM I concrete was also observed for Limestone Portland cement concrete, although at 28 days the reduction was less, being about 20 per cent at 60 °C. However, the performance of concretes containing fly ash and ggbs differed significantly from that of CEM I and LPC concretes in two principal respects. Firstly, at 28-days the *in situ* strength did not reduce with an increase in the peak temperature, with a trend for a higher *in situ* strength in those elements achieving the higher peak temperatures, at least up to about 60 °C. And secondly, the development of *in situ* strength over the long term was significantly higher for the fly ash and ggbs concretes. At 1 year, none of the elements containing pfa or ggbs exhibited strengths less than the 28-day cube strength, regardless of peak temperature, while for CEM I concrete, this was only achieved in concretes with peak early-age temperatures of less than about 40 °C.

Figure A9.5 illustrates more clearly the way in which the relative strength changes with age for concretes with the four cement types. Based on the best fit linear relationships derived for each data set, the results indicate that under conditions within which the peak temperature is likely to exceed 40 °C, concretes containing CEM I or Portland limestone cement are unlikely to achieve an *in situ* strength which exceeds the 28-day cube strength, even after one year. For the concretes containing fly ash and ggbs, however, the *in situ* strength had achieved the 28-day cube strength within 42 days, even when the peak temperature reached 60 °C. By comparison, CEM I concretes, even after 1 year, exhibited *in situ* strengths which were only about 85 per cent of the 28-day cube strength.

These findings are broadly consistent with those of Bamforth (1980) who measured the strength development for concretes containing fly ash (30 per cent) and ggbs (70 per cent) using temperature matched curing. Unlike CEM I concrete, for which the *in situ* strength was adversely affected at 28 days, in both cases the heat cycled strength exceeded the cube strength. This indicated that such mixes are far more tolerant to early temperature rise.

The difference between the performance of CEM I concrete and mixes containing fly ash and ggbs can have significant implications. It is clear from the results reported that for a given class of concrete, higher *in situ* strength will be achieved if the concrete contains fly ash or ggbs. In a study of fly ash concretes Bamforth (1984) indicated that in structural concrete in sections exposed to peak temperatures in the order of 70 °C, fly ash concrete achieves a heat cycled strength that may be 10MPa higher than the same class of concrete using CEM I. The converse of this is that to achieve the same *in situ* strength, a lower strength class may be used. Hence, under appropriate circumstances, it may be acceptable to not only benefit from the reduction in heat generation resulting from the inclusion of fly ash or ggbs, but also to achieve a lower

binder content associated with a lower strength class. This is similar in effect to specifying the strength at a later age, as sometimes occurs in practice.

An argument against utilizing the benefit from the early age temperature rise with fly ash and ggbs concretes has been that the surface is generally subjected to a lower temperature rise than the centre of a section. However, with the use of plywood formwork, the surface temperature may achieve a level at which it becomes significant and where knowledge is available on the construction process, consideration may be given to specifying either a lower strength class or later age compliance when using fly ash or ggbs concrete.

In order to understand the reasons for the observed scatter, the results have also been presented to show the effects of strength class (Figure A9.6), time of casting (Figure A9.7) and aggregate type (Figure A9.8).

Strength class

The results shown in Figure A9.6 indicate that the *in situ* strength for the lower strength concrete achieved a higher proportion of the cube strength at both 28 days and after 1 year. The difference is small but consistent across the range of mixes. The difference was most apparent for the fly ash concrete after one year and was least apparent for the ggbs concrete.

Time of casting

The results shown in Figure A9.7 indicate that the time of casting (winter or summer) had little effect on the relationship between *in situ* strength and cube strength for CEM I and PLC concretes. Similarly, after 1 year, the time of casting had little effect on the fly ash and ggbs concretes. However, the time of casting did have some effect on the *in situ* strength of these mixes at 28 days. As expected, the slower rate of hydration of these mixes resulted in lower early strengths, particularly when the peak temperature was low.

Aggregate type

Differences in the gradients of the best fit linear relationships between peak temperature and *in situ*/28-day cube strength indicate that the influence of peak temperature was more detrimental, (or less beneficial) in concrete containing limestone aggregate when compared with gravel aggregate concrete. This indicates that the effect of the early age temperature change is in part mechanical. The coefficient of thermal expansion of limestone is significantly lower than that of quartzite gravel and both are lower than the thermal expansion of cement paste. Hence changes in temperature in limestone aggregate concrete will result in greater differential expansion and contraction between the aggregate and cement paste, leading to localized thermal stresses that may cause micro-cracking and loss of strength. The average difference in the gradient was -0.0042 indicating that, over a temperature change of 40°C limestone aggregate concrete would achieve an *in situ* strength about 17 per cent less than achieved with a gravel aggregate concrete having the same strength at 20 °C. It was also observed, however, that the *in situ* strength of limestone aggregate concrete at 20 °C generally achieved a marginally higher proportion of the cube strength (by about 4 per cent), partially offsetting the effect of the subsequent change in temperature, which reduces to 13% on average at 60 °C.

A9.1.3 General conclusions relating to strength development

From the analysis of the Concrete Society study, the following may be concluded.

1. The strength development of CEM I concrete was adversely affected by the early temperature cycle to the extent that at 28 days the *in situ* strength may be only 65 per cent of the 28 day cube strength if the peak temperature reaches 60 °C. In the longer term the *in situ* strength increased but after 1 year it was still, on average, only about 85 per cent of the 28-day cube strength if the high peak temperature had been achieved.
2. Concrete containing Portland limestone cement was also adversely affected by the early thermal cycle but to a lesser extent than CEM I concrete. At 28 days the *in situ* strength was typically about 80 per cent of the 28 day cube strength, increasing to about 90 per cent after one year for concretes achieving 60 °C during the early thermal cycle.
3. The influence of the early thermal cycle on both fly ash and ggbs concretes was to enhance the *in situ* strength at 28 days such that it achieved 100 per cent of the 28 day cube strength within 42 days. After one year the *in situ* strength exceeded the 28-day cube strength by 10 per cent for

those concretes with the highest peak temperature and by a considerably higher margin for concretes experiencing lower peak temperatures.

4. For a given peak temperature, the lower grade of concrete achieved a higher proportion of the 28 day cube strength, with the difference being greatest during the early life of the concrete.
5. The time of casting (winter v summer) had little effect on the relationship between peak temperature and the *in situ* strength relative to the cube strength
6. The aggregate type was significant and indicates that the effect of the early temperature rise will be most detrimental (or less beneficial) for concrete containing lower thermal expansion aggregates (when comparing limestone with quartzite gravel).

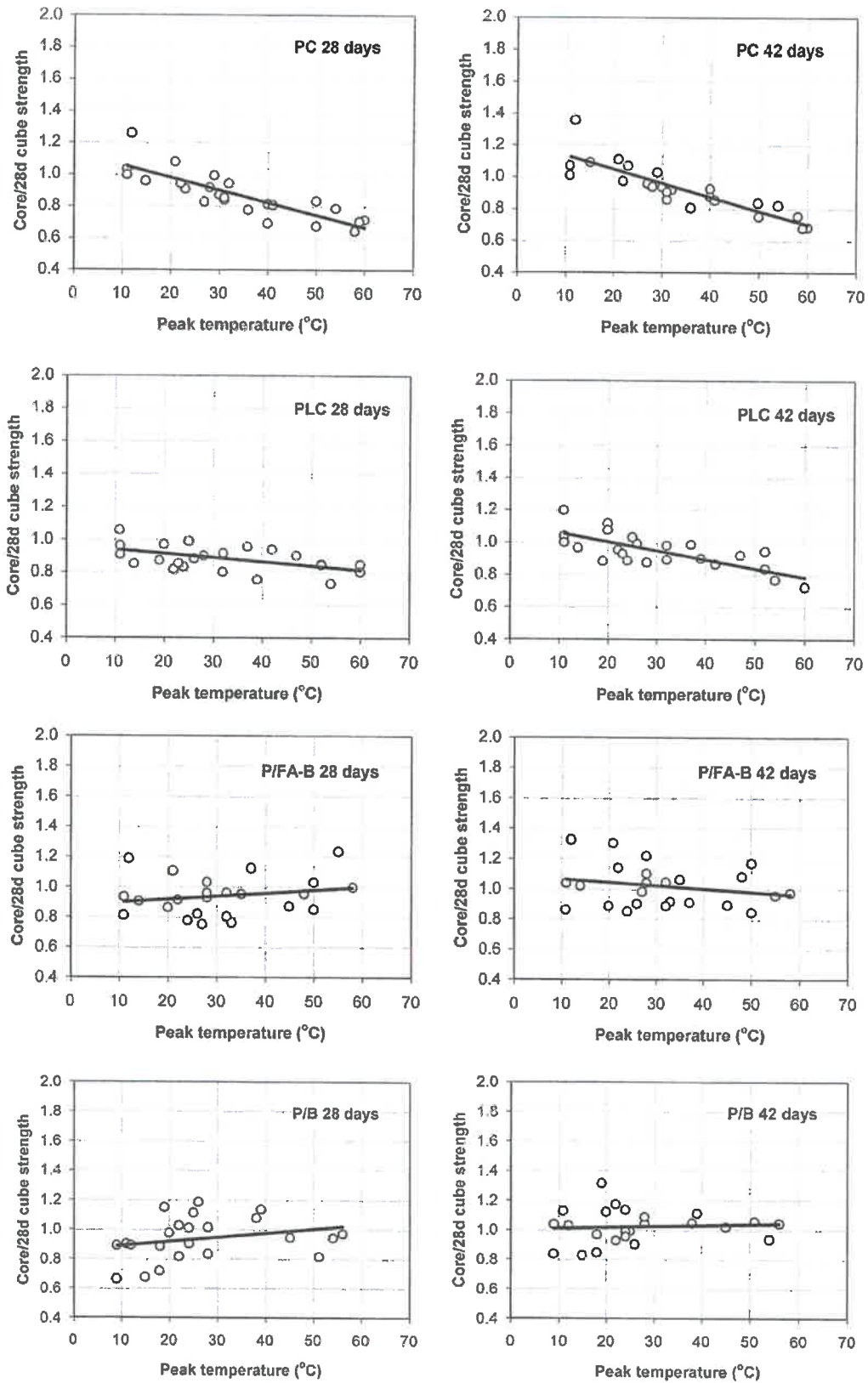


Figure A9.4 The influence of the peak temperature achieved during the early thermal cycle on the *in situ* strength of concrete (at 28 and 42 days) expressed in relation to the 28-day cube strength

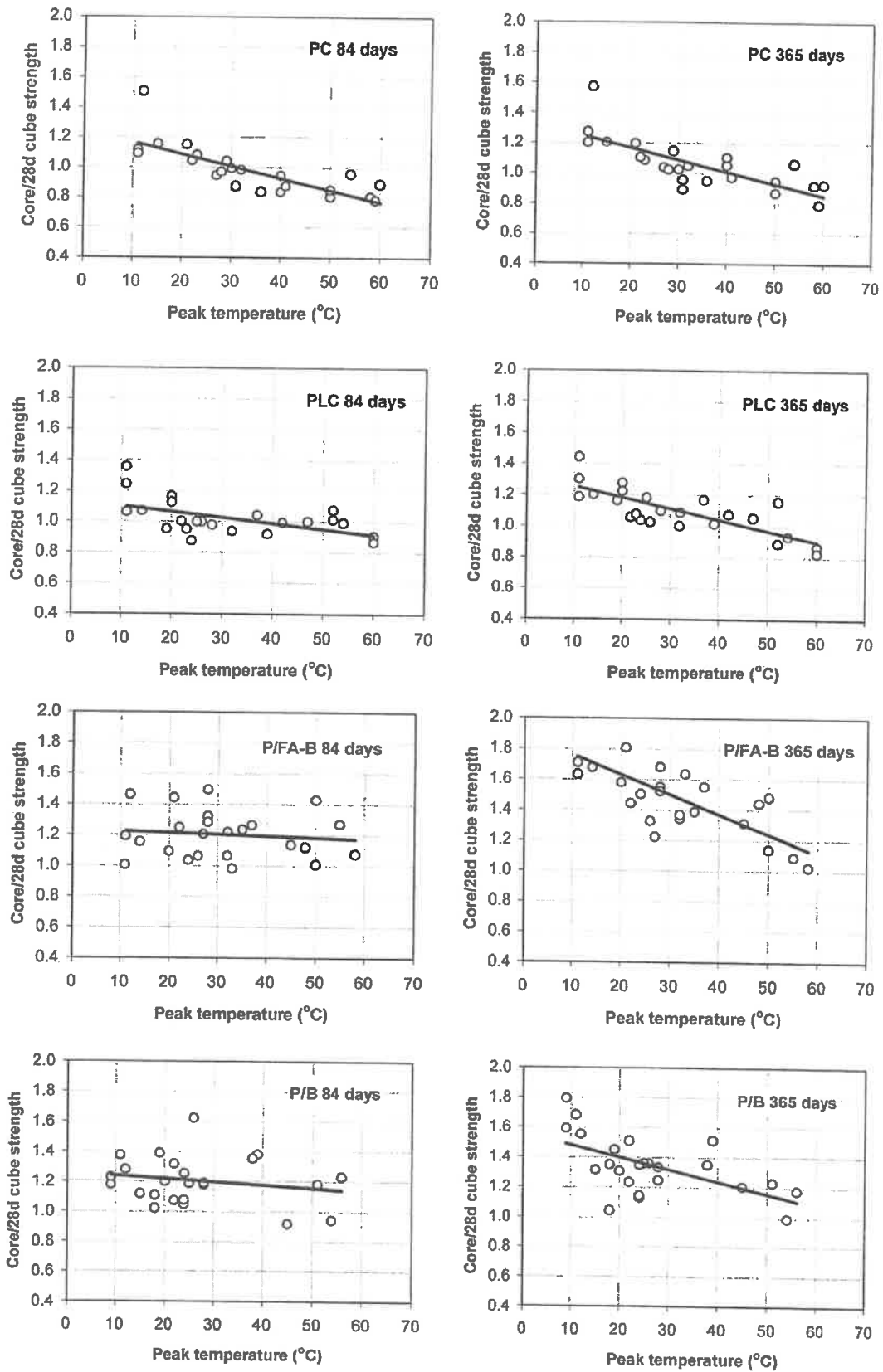


Figure A9.4 (contd) *The influence of the peak temperature achieved during the early thermal cycle on the insitu strength of concrete at 84 and 365 days expressed in relation to the 28-day cube strength*

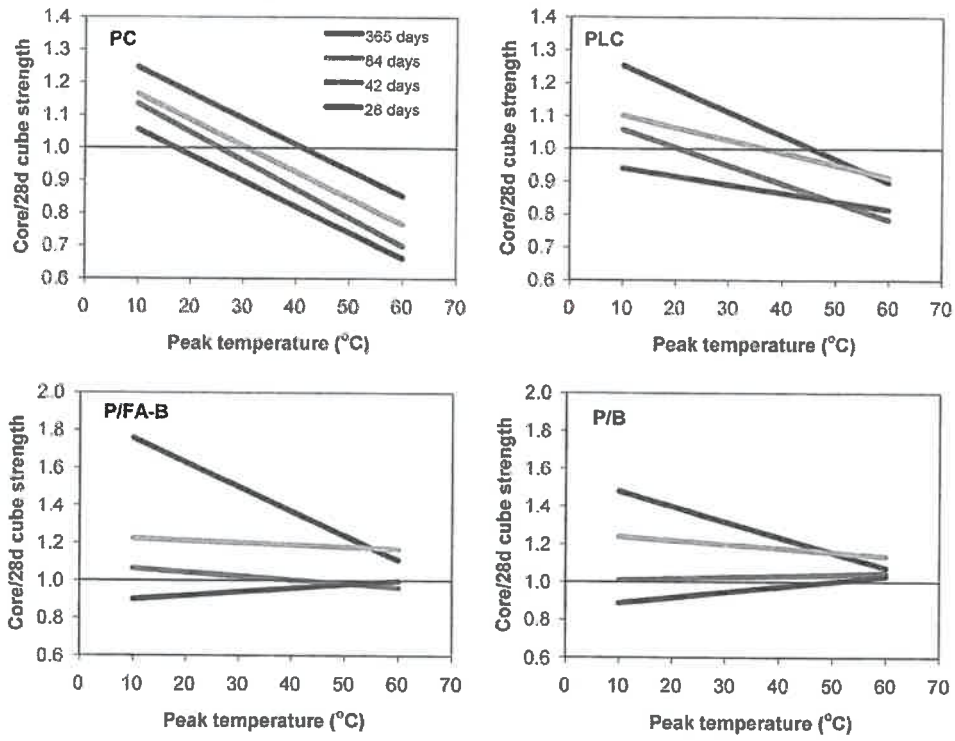


Figure A9.5 *The relationship between the peak temperature and the strength (relative to the 28-day cube) using CEM 1 cement, Portland limestone cement (PLC), and combinations of CEM 1 cement with 30 per cent fly ash cement (P/FA-B) and 50 per cent ggbs (P/B)*

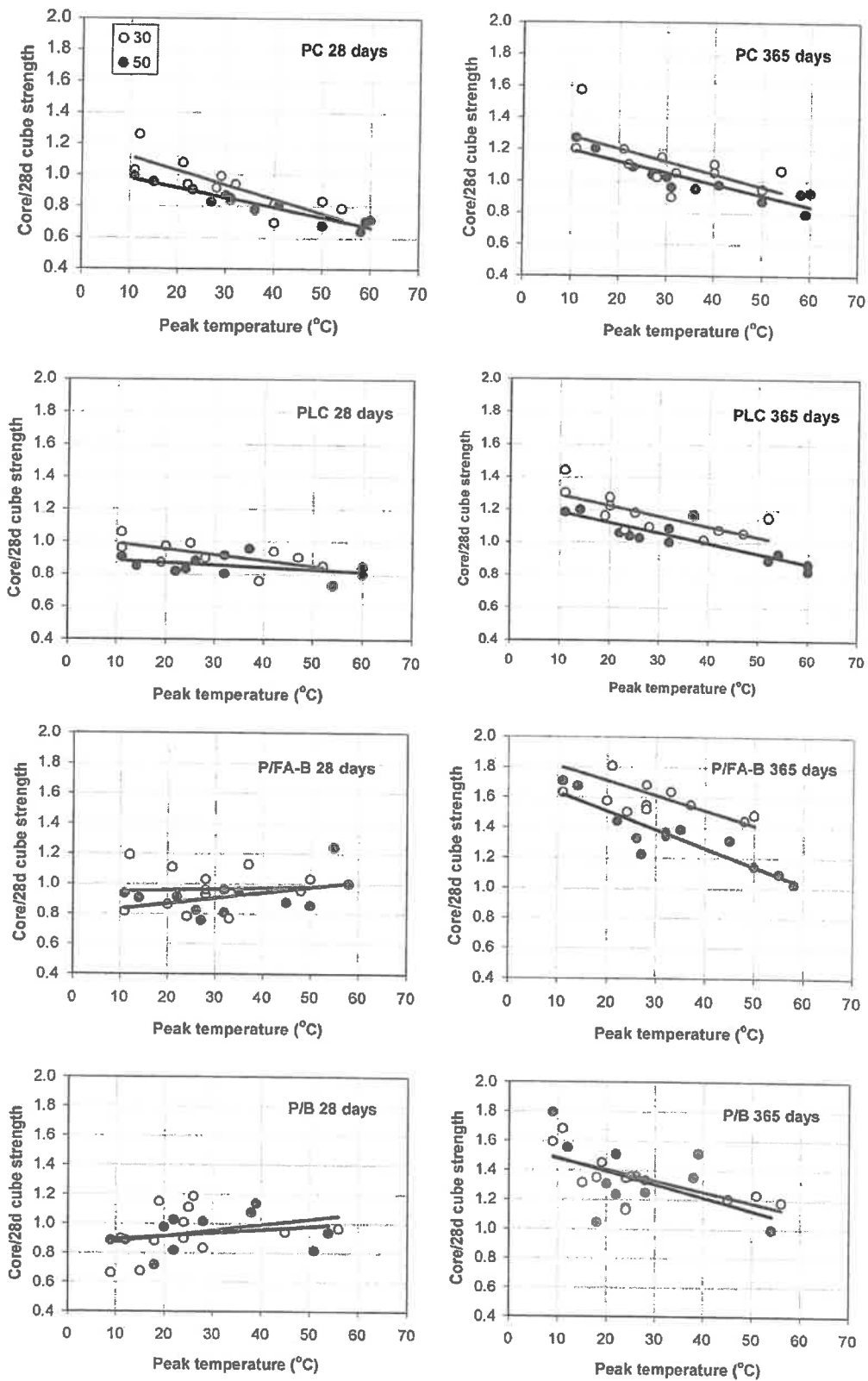


Figure A9.6 *The relationship between peak temperature and strength as affected by concrete strength class*

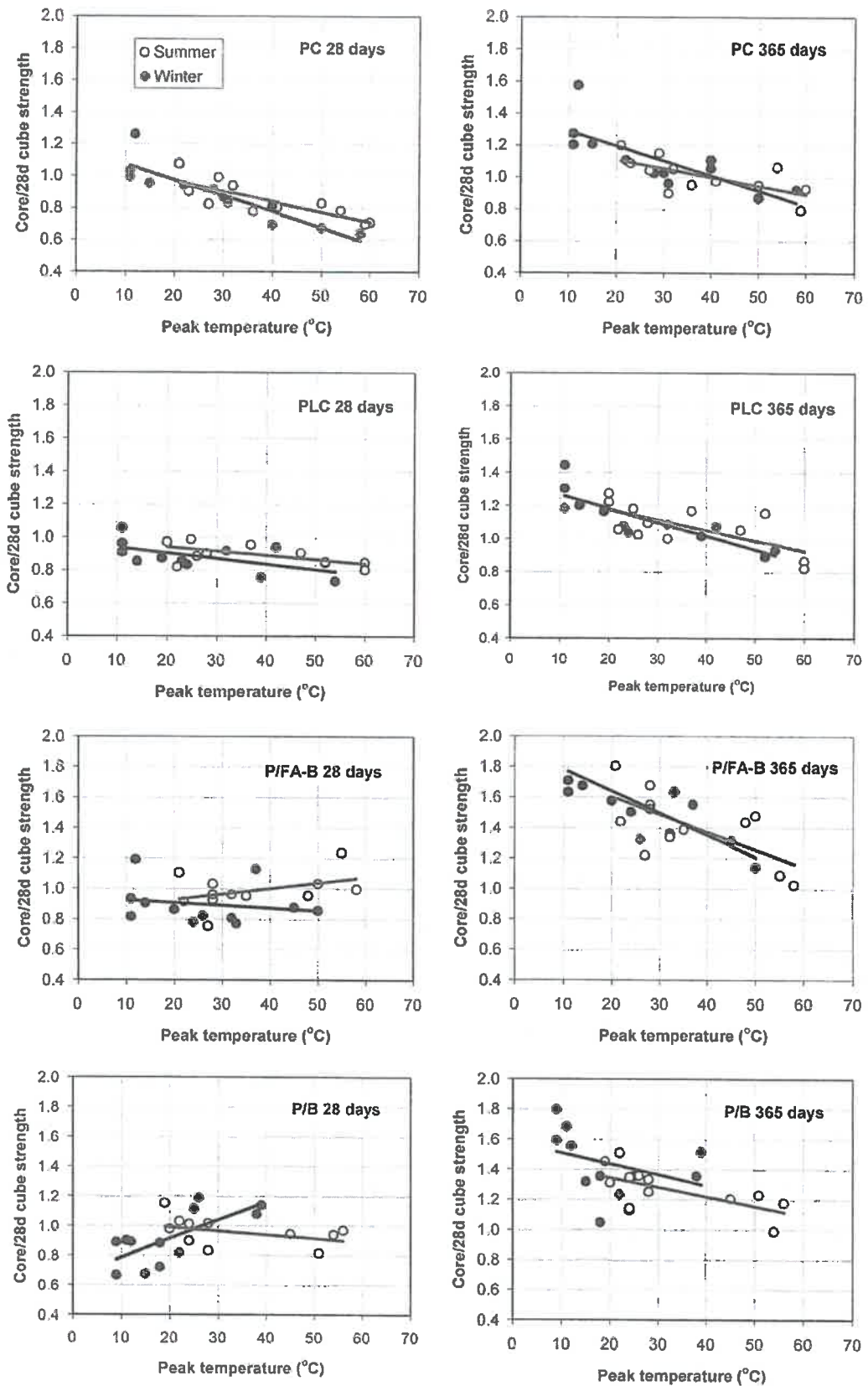


Figure A9.7 The relationship between peak temperature and strength as affected by the time of casting (summer v winter)

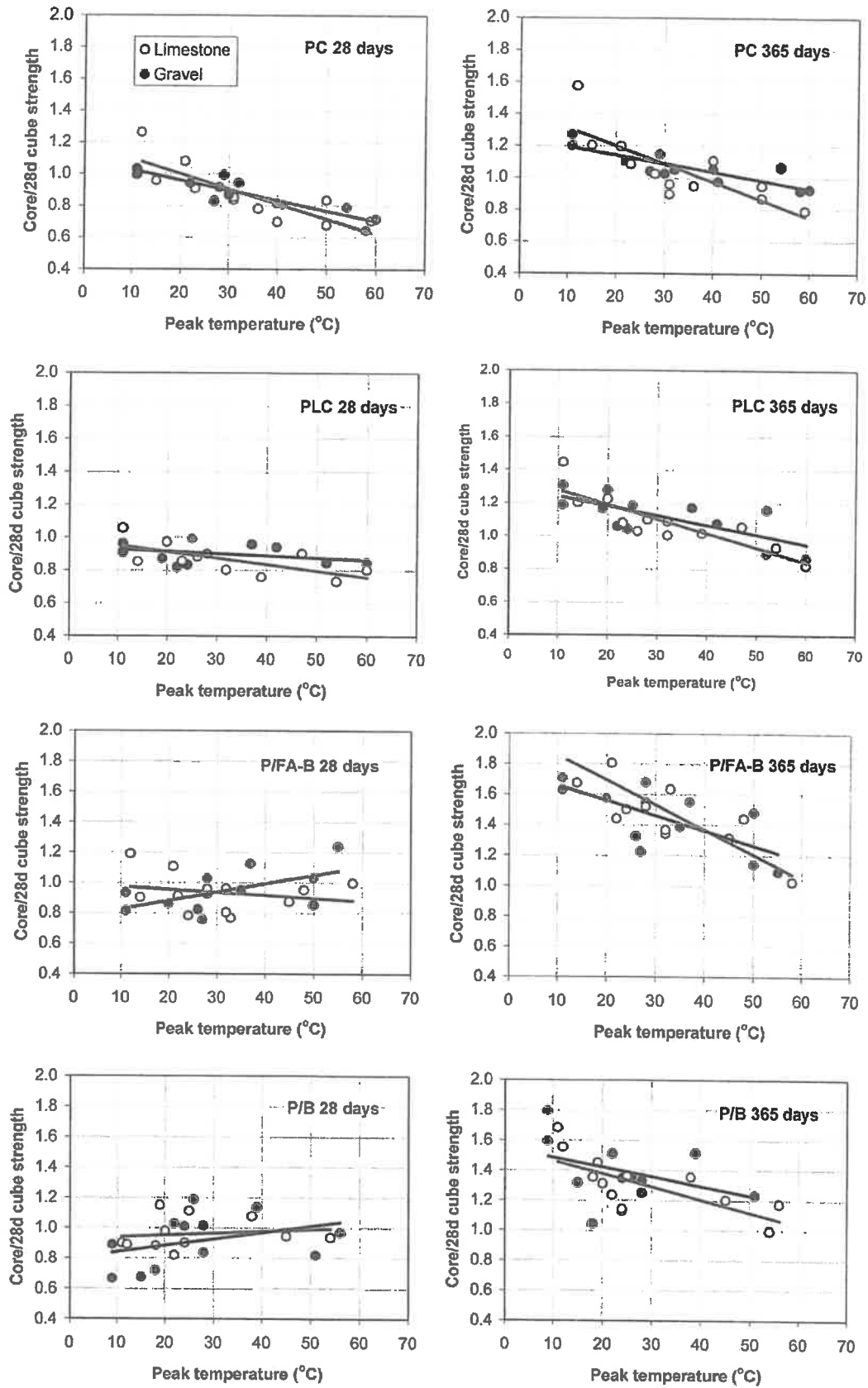


Figure A9.8 *The relationship between peak temperature and strength as affected by the aggregate type (limestone v gravel)*

A9.2 Durability

The influence of the early heat cycle on the durability of concrete does not appear to have been widely researched. If it is assumed that there is some correlation between durability and strength for a particular combination of constituent materials, it may be inferred from the Concrete Society study referred to in Section A9.1.2 that CEM I concrete may be adversely affected by the early thermal cycle, while concretes that contain fly ash and ggbs will benefit. However, there is not sufficient data to quantify the effect and enable its application in design.

In a study on high strength concrete containing fly ash, the influence of peak curing temperature on the Rapid Chloride Permeability was measured (Myers *et al*, 2000). An improvement was reported with increasing peak temperature up to about 88 °C. Interestingly, while there was a correlation between performance and peak temperature, no trend was observed with temperature rise. This suggests that the influence is most likely to have been related to chemical rather than physical processes.

A9.3 Delayed ettringite formation

Delayed ettringite formation (DEF) is a delayed form of sulphate attack and occurs in concrete which has a relatively high sulfate content and which has experienced high temperature during its early hydration. The high temperature decomposes the primary ettringite which is responsible for regulating set, and this reforms later in the life of the concrete. The following guidance is given in BRE IP11/01 (BRE, 2000) in relation to the risk of DEF.

- $T_p < 60$ °C no risk
- $T_p < 70$ °C very low risk
- $T_p < 80$ °C low risk

These above limits apply to Portland cement concretes. BRE IP11/01 states that pfa at levels of > 20 per cent or ggbs at levels of > 40 per cent will prevent DEF-induced expansion in concrete subject to peak temperatures of up to 100 °C.

Hence DEF may be prevented by limiting the peak temperature achieved during the early thermal cycle. The risk of DEF may be reduced most effectively by the use of fly ash or ggbs in suitable quantities which will have the combined effect of both reducing the temperature rise and increasing the temperature at which DEF will occur.

A9.4 Conclusions

The early-age peak temperature has a significant effect on the strength development of concrete. For concrete using CEM I the strength is impaired by the heat cycle such that at 28-days the heat cycled strength may be only 65 per cent of the standard cube strength. Concrete containing fly ash or ggbs are less adversely affected by the heat cycle and for the same class of concrete will achieve higher *in situ* strength. Hence, the same *in situ* compressive strength may be achieved with fly ash and ggbs concrete when using a lower strength class compared with CEM I concrete. For this reason it may be acceptable to measure compliance at an age later than 28 days (56 days is sometimes used) which is itself equivalent to using a lower strength class. This will enable a reduction in binder content, and hence a further reduction in temperature rise and the associated risk and/or extent of early-age thermal cracking.

A9.5 References

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Control of cracking due to internal restraint (Wall C40 & 24C)				
Input parameters	Symbol	Unit	Value	
Concrete and steel properties				
Section thickness	h	mm	1500	
Strength class	$f_{ch}/f_{st,sub}$	MPa	C30/37	
Age at cracking	t_c	days	3	Assume 3 days unless more reliable information is available
Creep factor	K_1		0.65	Default = 0.65
Sustained load factor	K_2		0.80	Default = 0.8
Coefficient of thermal expansion	α_c	$\mu\epsilon/PC$	10.0	If aggregate is unknown use 12
Characteristic yield strength of reinforcement	f_{yk}	MPa	500	500 MPa (EN1992-1-1)
Early-age concrete properties				
Tensile strength	$f_{ct,eff}$	MPa	1.73	Mean value of tensile strength, $f_{ctm}(t_c)$
Elastic modulus	E_c	GPa	28.1	Mean value of elastic modulus $E_{cm}(t_c)$
Tensile strain capacity under sustained loading	$\epsilon_{ct,s}$	$\mu\epsilon$	76	$\epsilon_{ct,s} = [f_{ctm}(t_c) / E_{cm}(t_c)] \times [K_2 / K_1]$
Early-age strain				
Temperature differential	ΔT	$^{\circ}C$	24	$\Delta T = \text{Peak temperature} - \text{surface temperature}$
Free differential strain	$\Delta\epsilon_{free}$	$\mu\epsilon$	240	$\Delta\epsilon_{free} = \Delta T \alpha_c$
Restraint	R		0.42	
Restrained differential strain	$\Delta\epsilon_r$	$\mu\epsilon$	66	$\Delta\epsilon_{(R+K)} = R, K, \Delta T \alpha_c$
Risk of early-age cracking	$\Delta\epsilon_r / \epsilon_{ct,s}$		0.86	Low risk of early-age cracking if $\Delta\epsilon_r / \epsilon_{ct,s} < 1$.
Crack-inducing differential strain	$\Delta\epsilon_{cr}$	$\mu\epsilon$	28	$\Delta\epsilon_{cr} = R, K, \Delta T \alpha_c - 0.5 \epsilon_{ct,s}$
Reinforcement details				
Bar diameter	ϕ	mm	35,35	
Bar spacing	S	mm	150	
Cover	c	mm	40	
Area of steel per face per m	A_s	mm^2	6543	
Early-age cracking				
Steel ratio for estimating $A_{s,min}$	f_{ctm}/f_{yk}		0.0035	$f_{ctm}/f_{yk} = \rho_{crit}$
Coefficient	k		1.0	
Coefficient	k_c		0.5	
Surface zone defining the area of concrete in the tensile zone A_{ct}	$h_{s,min}$	mm	300	$h_{s,min} = 0.2 h$
Minimum area of steel per face	$A_{s,min}$	mm^2	520	Highlighted if $A_s < A_{s,min}$
Surface zone defining the effective area of concrete in tension, $A_{p,eff}$	$h_{e,eff}$	mm	144.1675	$h_{e,eff} = 2.5 (c + \phi/2)$ [NB $h_{s,min}$ and $h_{e,eff}$ are not the same]
Steel ratio for calculating early-age crack spacing	$\rho_{p,eff}$		0.04538	$\rho_{p,eff} = A_s / A_{p,eff} = A_s / (h_{e,eff} \times 1000)$
Coefficient for bond characteristics	k_1		1.14	
Crack spacing	$s_{r,max}$	mm	513	$s_{r,max} = 3.4 c + 0.425 k_1 \phi / \rho_{p,eff}$
Crack width	w_k	mm	0.01	$w_k = \Delta\epsilon_{cr} s_{r,max}$

Risk and control of cracking due to continuous edge restraint (Wall C40 & 24C)					
Input parameters	Symbol	Unit	Value		CIRIA 91 BS8007
Section details and material properties					
Section thickness	h	mm	1500		500
Strength class	$f_{ck} / f_{ck,cubo}$	MPa	C30/37		
Age at cracking	t_c	days	3	Assume 3 days unless more reliable information is available	
Creep factor	K_1		0.65	$K_1 = 0.65$ if R is calculated; $K_1 = 1$ if R is assumed to be 0.5 (including creep to EN1992-1-1)	0.5
Sustained load factor	K_2		0.80		
Coefficient of thermal expansion of concrete	α_c	$\mu\epsilon/^\circ\text{C}$	10.0	If aggregate is unknown use $12 \mu\epsilon/^\circ\text{C}$	12
Characteristic yield strength of reinforcement	f_{yk}	MPa	500	500 Mpa	460
Early age concrete properties					
Tensile strength at cracking	$f_{ctm}(t_c)$	MPa	1.73	Mean value of tensile strength $f_{ctm}(t_c)$	1.61
Elastic modulus	$E_{cm}(t_c)$	GPa	28.1	Mean value of elastic modulus $E_{cm}(t_c)$	
Tensile strain capacity	$\epsilon_{ctm}(t_c)$	$\mu\epsilon$	76	$\epsilon_{ctm}(t_c) = [f_{ctm}(t_c) / E_{cm}(t_c)] \times [K_2 / K_1]$	65
Long term concrete properties					
Tensile strength	f_{ctm}	MPa	2.90	Mean 28-day value	
Elastic modulus	E_{cm}	GPa	32.8	Mean 28-day value	
Tensile strain capacity (sustained loading)	ϵ_{ctm}	$\mu\epsilon$	109	$\epsilon_{ctm} = [f_{ctm} / E_{cm}] \times [K_2 / K_1]$	130
Early-age strain					
Temperature drop	T_1	$^\circ\text{C}$	24	$T_1 =$ Peak temperature - mean ambient temperature	34
Autogenous shrinkage	$\epsilon_{ca}(t_c)$	$\mu\epsilon$	15	$EN1992-1-1 \epsilon_{ca}(t_c) = 2.5 (f_{ck} - 10) \times (1 - \exp(-0.2 t_c^{0.6}))$	
Free contraction	$\epsilon_{cs}(t_c)$	$\mu\epsilon$	255	$\epsilon_{cs}(t_c) = T_1 \alpha_c + \epsilon_{ca}$	408
Restrained early-age strain and risk of cracking					
Restraint	R		0.80	Use restraint calculator for walls or adjacent slabs, or historical data	1
Early-age restrained contraction	$\epsilon_{ra}(t_c)$	$\mu\epsilon$	132	$\epsilon_{ra}(t_c) = R_1 K_1 (T_1 \alpha_c + \epsilon_{ca})$	204
Risk of early age cracking	$\epsilon_{ra}(t_c) / \epsilon_{ctm}$		2.18	Low risk of early age cracking if $\epsilon_{ra}(t_c) / \epsilon_{ctm} < 1$.	3.14
Early-age crack-inducing strain	$\epsilon_{cr}(t_c)$	$\mu\epsilon$	95	$\epsilon_{cr}(t_c) = R_1 K_1 (T_1 \alpha_c + \epsilon_{ca}) - 0.5 \epsilon_{ctm}$	172
Long term strain (excluding early-age strain)					
Autogenous shrinkage (residual up to 28 days)	$\delta\epsilon_{ca}(t)$	$\mu\epsilon$	18	$\delta\epsilon_{ca}(t) = \epsilon_{ca}(28) - \epsilon_{ca}(t)$	
Long term temperature change	T_2	$^\circ\text{C}$	20	T_2 and ϵ_{cd} only apply when causing differential contraction or when the sections acting integrally are subject to external restraint.	20
Drying shrinkage	ϵ_{cd}	$\mu\epsilon$	150		100
Long term free contraction	$\epsilon_{cs}(t)$	$\mu\epsilon$	368	$\epsilon_{cs}(t) = \delta\epsilon_{ca} + T_2 \alpha_c + \epsilon_{cd}$	340
Restrained long term strain					
Restraint to long term thermal strains	R_2		0.80	Restraint will reduce as E_n / E_a approaches 1 in the long term	1
Restraint to drying shrinkage	R_3		0.80		1
Long term restrained strain	$\epsilon_{ra}(t)$	$\mu\epsilon$	191	$\epsilon_{ra}(t) = K_1 (R_2 T_2 \alpha_c + R_3 (\delta\epsilon_{ca} + \epsilon_{cd}))$	170
Increase in tensile strain capacity	$\delta\epsilon_{ctm}$	$\mu\epsilon$	33	$\delta\epsilon_{ctm} = \epsilon_{ctm}(28) - \epsilon_{ctm}(t_c)$	65
Long term crack-inducing strain	$\epsilon_{cr}(t)$	$\mu\epsilon$	159	$\epsilon_{cr}(t) = K_1 (R_2 T_2 \alpha_c + R_3 (\delta\epsilon_{ca} + \epsilon_{cd})) - \delta\epsilon_{ctm}$	105
Total strain (early-age + long term)					
Free contraction	$\epsilon_{cs}(t)$	$\mu\epsilon$	623	$\epsilon_{cs}(t) = \epsilon_{cs}(t_c) + \epsilon_{cs}(t)$	748
Restrained contraction	$\epsilon_{ra}(t)$	$\mu\epsilon$	324	$\epsilon_{ra}(t) = \epsilon_{ra}(t_c) + \epsilon_{ra}(t)$	374
Crack-inducing strain	$\epsilon_{cr}(t)$	$\mu\epsilon$	253	$\epsilon_{cr}(t) = \epsilon_{cr}(t_c) + \epsilon_{cr}(t)$	277
Reinforcement details					
Bar diameter	ϕ	mm	35,35		16
Bar spacing	s	mm	150		175
Cover	c	mm	40		40
Area of steel per face per m	A_s	mm^2	6543		1149
Cracking initiated at early age strain					
Minimum area of reinforcement $A_{s,min}$					
Steel ratio for early age cracking	f_{ctm} / f_{yk}		0.00347	$f_{ctm} / f_{yk} = \rho_{cr}$	0.0035
Coefficient	k		0.75	$k = 1.0$ for $h \leq 300\text{mm}$; $k = 0.75$ for $h \geq 800\text{mm}$; intermediate values are interpolated	
Coefficient	k_c		1	For pure tension $k_c = 1$	
Surface zone used in calculating $A_{s,min}$	$h_{s,min}$	mm	563	$h_{s,min} = k k_c h/2$	250
Minimum area of steel per face per m	$A_{s,min}$	mm^2	1949	$A_{s,min} = (h_{s,min} \times 1000) (f_{ctm} / f_{yk})$ Highlighted if $A_s < A_{s,min}$	875
Crack spacing and width					
Surface zone defining the effective area of concrete in tension, $A_{ce,eff}$	$h_{ce,eff}$	mm	144.1875	$h_{ce,eff} = 2.5 (c + \phi/2)$ [NOTE: $h_{s,min}$ and $h_{ce,eff}$ are not the same]	250
Steel ratio for estimating crack spacing	$\rho_{p,eff}$		0.04538	$\rho_{p,eff} = A_s / A_{ce,eff} = A_s / (h_{ce,eff} \times 1000)$	0.00460
Coefficient for bond characteristics	k_1		1.14	EN1992-1-1 recommends $k_1 = 0.8$ but provides a factor of 0.7 where good bond cannot be guaranteed. Hence $k_1 = 0.8/0.7 = 1.14$	0.67
Crack spacing	$S_{r,max}$	mm	513	$S_{r,max} = 3.4c + 0.425 k_1 \phi / \rho_{p,eff}$	1168
Early age crack width	w_k	mm	0.05	$w_k = \epsilon_{cr}(t_c) S_{r,max}$	0.20
Long term crack width	w_k	mm	0.13	$w_k = \epsilon_{cr}(t) S_{r,max}$	0.32
Minimum reinforcement requirement for late-life cracking only					
Steel ratio for late-life cracking	f_{ctm} / f_{yk}		0.0058	$f_{ctm} / f_{yk} = \rho_{cr}$	0.0033
Minimum area of steel per face	$A_{s,min}$	mm^2	3259	Highlighted if $A_s < A_{s,min}$	815

Control of cracking due to internal restraint (Wall C60 & 37C)				
Input parameters	Symbol	Unit	Value	
Concrete and steel properties				
Section thickness	h	mm	1500	
Strength class	$f_{ck} / f_{ck, cube}$	MPa	C50/60	
Age at cracking	t_c	days	3	Assume 3 days unless more reliable information is available
Creep factor	K_1		0.65	Default = 0.65
Sustained load factor	K_2		0.80	Default = 0.8
Coefficient of thermal expansion	α_c	$\mu\epsilon/^\circ\text{C}$	10.0	If aggregate is unknown use 12
Characteristic yield strength of reinforcement	f_{yk}	MPa	500	500 MPa (EN1992-1-1)
Early-age concrete properties				
Tensile strength	$f_{ct,eff}$	MPa	2.44	Mean value of tensile strength, $f_{ctm}(t_c)$
Elastic modulus	E_c	GPa	32.0	Mean value of elastic modulus $E_{cm}(t_c)$
Tensile strain capacity under sustained loading	$\epsilon_{ct,s}$	$\mu\epsilon$	94	$\epsilon_{ct,s} = [f_{ctm}(t_c) / E_{cm}(t_c)] \times [K_2 / K_1]$
Early-age strain				
Temperature differential	ΔT	$^\circ\text{C}$	37	$\Delta T = \text{Peak temperature} - \text{surface temperature}$
Free differential strain	$\Delta\epsilon_{free}$	$\mu\epsilon$	370	$\Delta\epsilon_{free} = \Delta T \alpha_c$
Restraint	R		0.42	
Restrained differential strain	$\Delta\epsilon_r$	$\mu\epsilon$	101	$\Delta\epsilon_{free} = R_1 K_1 \Delta T \alpha_c$
Risk of early-age cracking	$\Delta\epsilon_r / \epsilon_{ct,s}$		1.08	Low risk of early-age cracking if $\Delta\epsilon_r / \epsilon_{ct,s} < 1$.
Crack-inducing differential strain	$\Delta\epsilon_{cr}$	$\mu\epsilon$	54	$\Delta\epsilon_{cr} = R_1 K_1 \Delta T \alpha_c - 0.5 \epsilon_{ct,s}$
Reinforcement details				
Bar diameter	ϕ	mm	35,35	
Bar spacing	S	mm	150	
Cover	c	mm	40	
Area of steel per face per m	A_s	mm^2	6543	
Early-age cracking				
Steel ratio for estimating $A_{s,min}$	f_{ctm} / f_{yk}		0.0049	$f_{ctm} / f_{yk} = \rho_{crit}$
Coefficient	k		1.0	
Coefficient	k_c		0.5	
Surface zone defining the area of concrete in the tensile zone $A_{s,eff}$	$h_{a,eff}$	mm	300	$h_{a,min} = 0.2 h$
Minimum area of steel per face	$A_{s,min}$	mm^2	731	Highlighted if $A_s < A_{s,min}$
Surface zone defining the effective area of concrete in tension, $A_{s,eff}$	$h_{a,eff}$	mm	144.1875	$h_{a,eff} = 2.5 (c + \phi/2)$ [NB $h_{a,min}$ and $h_{a,eff}$ are not the same]
Steel ratio for calculating early-age crack spacing	$\rho_{p,eff}$		0.04538	$\rho_{p,eff} = A_s / A_{s,eff} = A_s / (h_{a,eff} \times 1000)$
Coefficient for bond characteristics	k_1		1.14	
Crack spacing	$s_{r,max}$	mm	513	$s_{r,max} = 3.4 c + 0.425 k_1 \phi / \rho_{p,eff}$
Crack width	w_k	mm	0.03	$w_k = \Delta\epsilon_{cr} s_{r,max}$

Risk and control of cracking due to continuous edge restraint (Wall C60 & 37C)					
Input parameters	Symbol	Unit	Value		CIRIA 91 BS8007
Section details and material properties					
Section thickness	h	mm	1500		500
Strength class	$f_{ck} / f_{ck,cube}$	MPa	C60/80		
Age at cracking	t_c	days	3	Assume 3 days unless more reliable information is available	
Creep factor	K_1		0.65	$K_1 = 0.65$ if R is calculated; $K_1 = 1$ if R is assumed to be 0.5 (including creep to EN1992-1-1)	0.5
Sustained load factor	K_2		0.80		
Coefficient of thermal expansion of concrete	α_c	$\mu\epsilon/^\circ\text{C}$	10.0	If aggregate is unknown use $12 \mu\epsilon / ^\circ\text{C}$	12
Characteristic yield strength of reinforcement	f_{yk}	MPa	500	500 Mpa	450
Early age concrete properties					
Tensile strength at cracking	$f_{ctm}(t_c)$	MPa	2.44	Mean value of tensile strength $f_{ctm}(t_c)$	1.61
Elastic modulus	$E_{cm}(t_c)$	GPa	32.0	Mean value of elastic modulus $E_{cm}(t_c)$	
Tensile strain capacity	$\epsilon_{ct,cr}(t_c)$	$\mu\epsilon$	94	$\epsilon_{ct,cr}(t_c) = [f_{ctm}(t_c) / E_{cm}(t_c)] \times [K_2 / K_1]$	65
Long term concrete properties					
Tensile strength	f_{ctm}	MPa	4.07	Mean 28-day value	
Elastic modulus	E_{cm}	GPa	37.3	Mean 28-day value	
Tensile strain capacity (sustained loading)	$\epsilon_{ct,s}$	$\mu\epsilon$	134	$\epsilon_{ct,s} = [f_{ctm} / E_{cm}] \times [K_2 / K_1]$	130
Early-age strain					
Temperature drop	T_1	$^\circ\text{C}$	37	$T_1 =$ Peak temperature - mean ambient temperature	34
Autogenous shrinkage	$\epsilon_{ca}(t_c)$	$\mu\epsilon$	29	EN1992-1-1 $\epsilon_{ca}(t_c) = 2.5 (f_{ck} - 10) \times (1 - \exp(-0.2 t_c^{0.5}))$	
Free contraction	$\epsilon_{free}(t_c)$	$\mu\epsilon$	399	$\epsilon_{free}(t_c) = T_1 \alpha_c + \epsilon_{ca}$	408
Restrained early-age strain and risk of cracking					
Restraint	R		0.80	Use restraint calculator for walls or adjacent slabs; or historical data	1
Early-age restrained contraction	$\epsilon_{ra}(t_c)$	$\mu\epsilon$	208	$\epsilon_{ra}(t_c) = R, K_1 (T_1 \alpha_c + \epsilon_{ca})$	204
Risk of early age cracking	$\epsilon_{ra}(t_c) / \epsilon_{ct,cr}$		2.77	Low risk of early age cracking if $\epsilon_{ra}(t_c) / \epsilon_{ct,cr} < 1$.	3.14
Early-age crack-inducing strain	$\epsilon_{cr}(t_c)$	$\mu\epsilon$	161	$\epsilon_{cr}(t_c) = R, K_1 (T_1 \alpha_c + \epsilon_{ca}) - 0.5 \epsilon_{ct,cr}$	172
Long term strain (excluding early-age strain)					
Autogenous shrinkage (residual up to 28 days)	$\delta \epsilon_{ca}(t_c)$	$\mu\epsilon$	36	$\delta \epsilon_{ca}(t_c) = \epsilon_{ca}(28) - \epsilon_{ca}(t_c)$	
Long term temperature change	T_2	$^\circ\text{C}$	20	T_2 and ϵ_{cd} only apply when causing differential contraction or when the sections acting integrally are subject to external restraint.	20
Drying shrinkage	ϵ_{cd}	$\mu\epsilon$	150		100
Long term free contraction	$\epsilon_{free}(t_c)$	$\mu\epsilon$	386	$\epsilon_{free}(t_c) = \delta \epsilon_{ca} + T_2 \alpha_c + \epsilon_{cd}$	340
Restrained long term strain					
Restraint to long term thermal strains	R_2		0.80	Restraint will reduce as E_n / E_o approaches 1 in the long term	1
Restraint to drying shrinkage	R_3		0.80		1
Long term restrained strain	$\epsilon_{rl}(t_c)$	$\mu\epsilon$	201	$\epsilon_{rl}(t_c) = K_1 (R_2 T_2 \alpha_c + R_3 (\delta \epsilon_{ca} + \epsilon_{cd}))$	170
Increase in tensile strain capacity	$\delta \epsilon_{ct,s}$	$\mu\epsilon$	41	$\delta \epsilon_{ct,s} = \epsilon_{ct,s}(28) - \epsilon_{ct,s}(t_c)$	65
Long term crack-inducing strain	$\epsilon_{cr}(t_c)$	$\mu\epsilon$	160	$\epsilon_{cr}(t_c) = K_1 (R_2 T_2 \alpha_c + R_3 (\delta \epsilon_{ca} + \epsilon_{cd})) - \delta \epsilon_{ct,s}$	105
Total strain (early-age + long term)					
Free contraction	$\epsilon_{free}(t_c)$	$\mu\epsilon$	785	$\epsilon_{free}(t_c) = \epsilon_{free}(t_c) + \epsilon_{free}(t_c)$	748
Restrained contraction	$\epsilon_{ra}(t_c)$	$\mu\epsilon$	408	$\epsilon_{ra}(t_c) = \epsilon_{ra}(t_c) + \epsilon_{rl}(t_c)$	374
Crack-inducing strain	$\epsilon_{cr}(t_c)$	$\mu\epsilon$	321	$\epsilon_{cr}(t_c) = \epsilon_{cr}(t_c) + \epsilon_{cr}(t_c)$	277
Reinforcement details					
Bar diameter	ϕ	mm	35.35		16
Bar spacing	s	mm	150		175
Cover	c	mm	40		40
Area of steel per face per m	A_s	mm^2	6543		1149
Cracking initiated at early age strain					
Minimum area of reinforcement $A_{s,min}$					
Steel ratio for early age cracking	f_{ctm} / f_{yk}		0.00487	$f_{ctm} / f_{yk} = \rho_{ct}$	0.0035
Coefficient	k		0.75	$k = 1.0$ for $h \leq 300\text{mm}$; $k = 0.75$ for $h \geq 800\text{mm}$; intermediate values are interpolated	
Coefficient	k_c		1	For pure tension $k_c = 1$	
Surface zone used in calculating $A_{s,min}$	$h_{s,min}$	mm	563	$h_{s,min} = k k_c h / 2$	250
Minimum area of steel per face per m	$A_{s,min}$	mm^2	2740	$A_{s,min} = (h_{s,min} \times 1000) (f_{ctm} / f_{yk})$ Highlighted if $A_s < A_{s,min}$	876
Crack spacing and width					
Surface zone defining the effective area of concrete in tension, $A_{e,eff}$	$h_{e,eff}$	mm	144.1875	$h_{e,eff} = 2.5 (c + \phi/2)$ [NOTE: $h_{s,min}$ and $h_{e,eff}$ are not the same]	250
Steel ratio for estimating crack spacing	$\rho_{p,eff}$		0.04538	$\rho_{p,eff} = A_s / A_{e,eff} = A_s / (h_{e,eff} \times 1000)$	0.00460
Coefficient for bond characteristics	k_1		1.14	EN1992-1-1 recommends $k_1 = 0.8$ but provides a factor of 0.7 where good bond cannot be guaranteed. Hence $k_1 = 0.8/0.7 = 1.14$	0.67
Crack spacing	$S_{r,max}$	mm	513	$S_{r,max} = 3.4c + 0.425 k_1 \phi / \rho_{p,eff}$	1166
Early age crack width	w_k	mm	0.08	$w_k = \epsilon_{cr}(t_c) S_{r,max}$	0.20
Long term crack width	w_k	mm	0.16	$w_k = \epsilon_{cr}(t_c) S_{r,max}$	0.32
Minimum reinforcement requirement for late-life cracking only					
Steel ratio for late-life cracking	f_{ctm} / f_{yk}		0.0081	$f_{ctm} / f_{yk} = \rho_{ct}$	0.0033
Minimum area of steel per face	$A_{s,min}$	mm^2	4581	Highlighted if $A_s < A_{s,min}$	815

Control of cracking due to internal restraint (Base slab C40 & 24C)				
Input parameters	Symbol	Unit	Value	
Concrete and steel properties				
Section thickness	h	mm	<u>2500</u>	
Strength class	$f_{ck}/f_{ck,cube}$	MPa	<u>C30/37</u>	
Age at cracking	t_c	days	<u>3</u>	Assume 3 days unless more reliable information is available
Creep factor	K_1		<u>0.66</u>	Default = 0.85
Sustained load factor	K_2		<u>0.80</u>	Default = 0.8
Coefficient of thermal expansion	α_c	$\mu\epsilon/^\circ\text{C}$	<u>10.0</u>	If aggregate is unknown use 12
Characteristic yield strength of reinforcement	f_{yk}	MPa	<u>500</u>	500 MPa (EN1992-1-1)
Early-age concrete properties				
Tensile strength	$f_{ct,eff}$	MPa	1.73	Mean value of tensile strength, $f_{ct}(t_c)$
Elastic modulus	E_c	GPa	28.1	Mean value of elastic modulus $E_{cm}(t_c)$
Tensile strain capacity under sustained loading	$\epsilon_{ct,s}$	$\mu\epsilon$	76	$\epsilon_{ct,s} = [f_{ct}(t_c)/E_{cm}(t_c)] \times [K_2/K_1]$
Early-age strain				
Temperature differential	ΔT	$^\circ\text{C}$	<u>24</u>	$\Delta T = \text{Peak temperature} - \text{surface temperature}$
Free differential strain	$\Delta\epsilon_{free}$	$\mu\epsilon$	240	$\Delta\epsilon_{free} = \Delta T \alpha_c$
Restraint	R		0.42	
Restrained differential strain	$\Delta\epsilon_r$	$\mu\epsilon$	66	$\Delta\epsilon_{r(s)} = R, K_1, \Delta T \alpha_c$
Risk of early-age cracking	$\Delta\epsilon_r/\epsilon_{ct,s}$		0.86	Low risk of early-age cracking if $\Delta\epsilon_r/\epsilon_{ct,s} < 1$
Crack-inducing differential strain	$\Delta\epsilon_{cr}$	$\mu\epsilon$	28	$\Delta\epsilon_{cr} = R, K_2, \Delta T \alpha_c - 0.5 \epsilon_{ct,s}$
Reinforcement details				
Bar diameter	ϕ	mm	<u>56.67</u>	
Bar spacing	S	mm	<u>150</u>	
Cover	c	mm	<u>40</u>	
Area of steel per face per m	A_s	mm^2	16756	
Early-age cracking				
Steel ratio for estimating $A_{s,min}$	f_{ctm}/f_{yk}		0.0035	$f_{ctm}/f_{yk} = \rho_{crit}$
Coefficient	k		1.0	
Coefficient	k_c		0.5	
Surface zone defining the area of concrete in the tensile zone A_{ct}	$h_{s,min}$	mm	500	$h_{s,min} = 0.2 h$
Minimum area of steel per face	$A_{s,min}$	mm^2	866	Highlighted if $A_s < A_{s,min}$
Surface zone defining the effective area of concrete in tension, $A_{c,eff}$	$h_{e,ef}$	mm	170.7125	$h_{e,ef} = 2.5(c + \phi/2)$ [NB $h_{s,min}$ and $h_{e,ef}$ are not the same]
Steel ratio for calculating early-age crack spacing	$\rho_{s,ef}$		0.09815	$\rho_{s,ef} = A_s/A_{c,eff} = A_s/(h_{e,ef} \times 1000)$
Coefficient for bond characteristics	k_f		<u>1.14</u>	
Crack spacing	$S_{r,max}$	mm	415	$S_{r,max} = 3.4 c + 0.425 k_f \phi / \rho_{s,ef}$
Crack width	w_k	mm	0.01	$w_k = \Delta\epsilon_{cr} S_{r,max}$

Risk and control of cracking due to continuous edge restraint (Base slab C40 & 24C)					
Input parameters	Symbol	Unit	Value		CIRIA 91 BS8007
Section details and material properties					
Section thickness	h	mm	2500		500
Strength class	$f_{ck} / f_{ck,cube}$	MPa	C30/37		
Age at cracking	t_c	days	3	Assume 3 days unless more reliable information is available	
Creep factor	K_1		0.65	$K_1 = 0.65$ if R is calculated; $K_1 = 1$ if R is assumed to be 0.5 (including creep to EN1992-1-1)	0.5
Sustained load factor	K_2		0.80		
Coefficient of thermal expansion of concrete	α_c	$\mu\epsilon/^\circ\text{C}$	10.0	If aggregate is unknown use $12 \mu\epsilon / ^\circ\text{C}$	12
Characteristic yield strength of reinforcement	f_{yk}	MPa	500	500 Mpa	460
Early age concrete properties					
Tensile strength at cracking	$f_{ctm}(t_c)$	MPa	1.73	Mean value of tensile strength $f_{ctm}(t_c)$	1.61
Elastic modulus	$E_{cm}(t_c)$	GPa	28.1	Mean value of elastic modulus $E_{cm}(t_c)$	
Tensile strain capacity	$\epsilon_{ct,cr}(t_c)$	$\mu\epsilon$	76	$\epsilon_{ct,cr}(t_c) = [f_{ctm}(t_c) / E_{cm}(t_c)] \times [K_2 / K_1]$	65
Long term concrete properties					
Tensile strength	f_{ctm}	MPa	2.90	Mean 28-day value	
Elastic modulus	E_{cm}	GPa	32.8	Mean 28-day value	
Tensile strain capacity (sustained loading)	$\epsilon_{ct,s}(t)$	$\mu\epsilon$	109	$\epsilon_{ct,s}(t) = [f_{ctm} / E_{cm}] \times [K_2 / K_1]$	130
Early-age strain					
Temperature drop	T_1	$^\circ\text{C}$	24	$T_1 =$ Peak temperature - mean ambient temperature	34
Autogenous shrinkage	$\epsilon_{ca}(t_c)$	$\mu\epsilon$	15	EN1992-1-1 $\epsilon_{ca}(t_c) = 2.5 (f_{ck} - 10) \times (1 - \exp(-0.2 t_c^{0.5}))$	
Free contraction	$\epsilon_{free}(t_c)$	$\mu\epsilon$	255	$\epsilon_{free}(t_c) = T_1 \alpha_c + \epsilon_{ca}$	408
Restrained early-age strain and risk of cracking					
Restraint	R		0.80	Use restraint calculator for walls or adjacent slabs; or historical data	1
Early-age restrained contraction	$\epsilon_{r,ea}(t_c)$	$\mu\epsilon$	132	$\epsilon_{r,ea}(t_c) = R_1 K_1 (T_1 \alpha_c + \epsilon_{ca})$	204
Risk of early age cracking	$\epsilon_{r,ea}(t_c) / \epsilon_{ct,cr}$		2.18	Low risk of early age cracking if $\epsilon_{r,ea}(t_c) / \epsilon_{ct,cr} < 1$.	3.14
Early-age crack-inducing strain	$\epsilon_{cr,ea}(t_c)$	$\mu\epsilon$	95	$\epsilon_{cr,ea}(t_c) = R_1 K_1 (T_1 \alpha_c + \epsilon_{ca}) - 0.5 \epsilon_{ct,cr}$	172
Long term strain (excluding early-age strain)					
Autogenous shrinkage (residual up to 28 days)	$\delta \epsilon_{ca}(t)$	$\mu\epsilon$	18	$\delta \epsilon_{ca}(t) = \epsilon_{ca}(t) - \epsilon_{ca}(t_c)$	
Long term temperature change	T_2	$^\circ\text{C}$	20	T_2 and ϵ_{cd} only apply when causing differential contraction or when the sections acting integrally are subject to external restraint.	20
Drying shrinkage	ϵ_{cd}	$\mu\epsilon$	150		100
Long term free contraction	$\epsilon_{free}(t)$	$\mu\epsilon$	368	$\epsilon_{free}(t) = \delta \epsilon_{ca} + T_2 \alpha_c + \epsilon_{cd}$	340
Restrained long term strain					
Restraint to long term thermal strains	R_2		0.80	Restraint will reduce as E_p / E_c approaches 1 in the long term	1
Restraint to drying shrinkage	R_3		0.80		1
Long term restrained strain	$\epsilon_{r,lt}(t)$	$\mu\epsilon$	191	$\epsilon_{r,lt}(t) = K_1 (R_2 T_2 \alpha_c + R_3 (\delta \epsilon_{ca} + \epsilon_{cd}))$	170
Increase in tensile strain capacity	$\delta \epsilon_{ct}$	$\mu\epsilon$	33	$\delta \epsilon_{ct} = \epsilon_{ct}(t) - \epsilon_{ct}(t_c)$	65
Long term crack-inducing strain	$\epsilon_{cr,lt}(t)$	$\mu\epsilon$	159	$\epsilon_{cr,lt}(t) = K_1 (R_2 T_2 \alpha_c + R_3 (\delta \epsilon_{ca} + \epsilon_{cd})) - \delta \epsilon_{ct}$	105
Total strain (early-age + long term)					
Free contraction	$\epsilon_{free}(t)$	$\mu\epsilon$	623	$\epsilon_{free}(t) = \epsilon_{free}(t_c) + \epsilon_{free}(t)$	748
Restrained contraction	$\epsilon_{r,lt}(t)$	$\mu\epsilon$	324	$\epsilon_{r,lt}(t) = \epsilon_{r,ea}(t_c) + \epsilon_{r,lt}(t)$	374
Crack-inducing strain	$\epsilon_{cr}(t)$	$\mu\epsilon$	253	$\epsilon_{cr}(t) = \epsilon_{cr,ea}(t_c) + \epsilon_{cr,lt}(t)$	277
Reinforcement details					
Bar diameter	ϕ	mm	56.57		16
Bar spacing	s	mm	150		175
Cover	c	mm	40		40
Area of steel per face per m	A_s	mm^2	16756		1149
Cracking initiated at early age strain					
Minimum area of reinforcement $A_{s,min}$					
Steel ratio for early age cracking	f_{ctm} / f_{yk}		0.00347	$f_{ctm} / f_{yk} = \rho_{ct}$	0.0035
Coefficient	k		0.75	$k = 1.0$ for $h \leq 300\text{mm}$; $k = 0.75$ for $h \geq 800\text{mm}$; intermediate values are interpolated	
Coefficient	k_c		1	For pure tension $k_c = 1$	
Surface zone used in calculating $A_{s,min}$	$h_{s,min}$	mm	938	$h_{s,min} = k k_c h / 2$	250
Minimum area of steel per face per m	$A_{s,min}$	mm^2	3249	$A_{s,min} = (h_{s,min} \times 1000) (f_{ctm} / f_{yk})$ Highlighted if $A_s < A_{s,min}$	875
Crack spacing and width					
Surface zone defining the effective area of concrete in tension, $A_{s,eff}$	$h_{e,eff}$	mm	170.7125	$h_{e,eff} = 2.5 (c + \phi / 2)$ [NOTE: $h_{s,min}$ and $h_{e,eff}$ are not the same]	250
Steel ratio for estimating crack spacing	$\rho_{s,eff}$		0.09815	$\rho_{s,eff} = A_s / A_{s,eff} = A_s / (h_{e,eff} \times 1000)$	0.00460
Coefficient for bond characteristics	k_1		1.14	EN1992-1-1 recommends $k_1 = 0.8$ but provides a factor of 0.7 where good bond cannot be guaranteed. Hence $k_1 = 0.8/0.7 = 1.14$	0.67
Crack spacing	$S_{r,max}$	mm	415	$S_{r,max} = 3.4c + 0.425 k_1 \phi / \rho_{s,eff}$	1166
Early age crack width	w_k	mm	0.04	$w_k = \epsilon_{cr,ea}(t_c) S_{r,max}$	0.20
Long term crack width	w_k	mm	0.11	$w_k = \epsilon_{cr}(t) S_{r,max}$	0.32
Minimum reinforcement requirement for late-life cracking only					
Steel ratio for late-life cracking	f_{ctm} / f_{yk}		0.0058	$f_{ctm} / f_{yk} = \rho_{ct}$	0.0033
Minimum area of steel per face	$A_{s,min}$	mm^2	5431	Highlighted if $A_s < A_{s,min}$	815

Control of cracking due to internal restraint (Base slab C60 & 35C)				
Input parameters	Symbol	Unit	Value	
Concrete and steel properties				
Section thickness	h	mm	<u>2500</u>	
Strength class	$f_{ck}/f_{yk,cube}$	MPa	<u>C50/60</u>	
Age at cracking	t_c	days	<u>3</u>	Assume 3 days unless more reliable information is available
Creep factor	K_1		<u>0.65</u>	Default = 0.65
Sustained load factor	K_2		<u>0.80</u>	Default = 0.8
Coefficient of thermal expansion	α_c	$\mu\epsilon/^\circ\text{C}$	<u>10.0</u>	If aggregate is unknown use 12
Characteristic yield strength of reinforcement	f_{ky}	MPa	<u>500</u>	500 MPa (EN1992-1-1)
Early-age concrete properties				
Tensile strength	$f_{ct,eff}$	MPa	2.44	Mean value of tensile strength, $f_{ctm}(t_c)$
Elastic modulus	E_c	GPa	32.0	Mean value of elastic modulus $E_{cm}(t_c)$
Tensile strain capacity under sustained loading	ϵ_{cs}	$\mu\epsilon$	94	$\epsilon_{cs} = [f_{ctm}(t_c)/E_{cm}(t_c)] \times [K_2/K_1]$
Early-age strain				
Temperature differential	ΔT	$^\circ\text{C}$	<u>35</u>	$\Delta T = \text{Peak temperature} - \text{surface temperature}$
Free differential strain	$\Delta\epsilon_{free}$	$\mu\epsilon$	350	$\Delta\epsilon_{free} = \Delta T \alpha_c$
Restraint	R		0.42	
Restrained differential strain	$\Delta\epsilon_r$	$\mu\epsilon$	95	$\Delta\epsilon_{(95)} = R, K_1 \Delta T \alpha_c$
Risk of early-age cracking	$\Delta\epsilon_r / \epsilon_{cs}$		1.02	Low risk of early-age cracking if $\Delta\epsilon_r / \epsilon_{cs} < 1$
Crack-inducing differential strain	$\Delta\epsilon_{cr}$	$\mu\epsilon$	49	$\Delta\epsilon_{cr} = R, K_1 \Delta T \alpha_c - 0.5 \epsilon_{cs}$
Reinforcement details				
Bar diameter	φ	mm	<u>56.57</u>	
Bar spacing	S	mm	<u>150</u>	
Cover	c	mm	<u>40</u>	
Area of steel per face per m	A_s	mm^2	16756	
Early-age cracking				
Steel ratio for estimating $A_{s,min}$	f_{ctm}/f_{yk}		0.0049	$f_{ctm}/f_{yk} = \rho_{crit}$
Coefficient	k		1.0	
Coefficient	k_c		0.5	
Surface zone defining the area of concrete in the tensile zone A_{ct}	$h_{s,min}$	mm	500	$h_{s,min} = 0.2 h$
Minimum area of steel per face	$A_{s,min}$	mm^2	1218	Highlighted if $A_s < A_{s,min}$
Surface zone defining the effective area of concrete in tension, $A_{c,eff}$	$h_{s,ef}$	mm	170.7125	$h_{s,ef} = 2.5(c + \varphi/2)$ [NB $h_{s,min}$ and $h_{s,ef}$ are not the same]
Steel ratio for calculating early-age crack spacing	$\rho_{p,eff}$		0.09815	$\rho_{p,eff} = A_s / A_{c,eff} = A_s / (h_{s,ef} \times 1000)$
Coefficient for bond characteristics	k_f		<u>1.14</u>	
Crack spacing	$s_{r,max}$	mm	415	$s_{r,max} = 3.4 c + 0.425 k_f \varphi / \rho_{p,eff}$
Crack width	w_k	mm	0.02	$w_k = \Delta\epsilon_{cr} S_{r,max}$

Risk and control of cracking due to continuous edge restraint (Base slab C60 & 35C)					
Input parameters	Symbol	Unit	Value		CIRIA 91 BS8007
Section details and material properties					
Section thickness	h	mm	2500		500
Strength class	$f_{ck} / f_{ck,edge}$	MPa	C60/60		
Age at cracking	t_c	days	3	Assume 3 days unless more reliable information is available	
Creep factor	K_1		0.65	$K_1 = 0.65$ if R is calculated; $K_1 = 1$ if R is assumed to be 0.5 (including creep to EN1992-1-1)	0.5
Sustained load factor	K_2		0.90		
Coefficient of thermal expansion of concrete	α_c	$\mu\epsilon/^\circ\text{C}$	10.0	If aggregate is unknown use $12 \mu\epsilon / ^\circ\text{C}$	12
Characteristic yield strength of reinforcement	f_{yk}	MPa	500	500 Mpa	460
Early age concrete properties					
Tensile strength at cracking	$f_{ctm}(t_c)$	MPa	2.44	Mean value of tensile strength $f_{ctm}(t_c)$	1.61
Elastic modulus	$E_{cm}(t_c)$	GPa	32.0	Mean value of elastic modulus $E_{cm}(t_c)$	
Tensile strain capacity	$\epsilon_{ct,cr}(t_c)$	$\mu\epsilon$	94	$\epsilon_{ct,cr}(t_c) = [f_{ctm}(t_c) / E_{cm}(t_c)] \times [K_2 / K_1]$	65
Long term concrete properties					
Tensile strength	f_{ctm}	MPa	4.07	Mean 28-day value	
Elastic modulus	E_{cm}	GPa	37.3	Mean 28-day value	
Tensile strain capacity (sustained loading)	$\epsilon_{ct,st}$	$\mu\epsilon$	134	$\epsilon_{ct,st} = [f_{ctm} / E_{cm}] \times [K_2 / K_1]$	130
Early-age strain					
Temperature drop	T_1	$^\circ\text{C}$	35	$T_1 =$ Peak temperature - mean ambient temperature	34
Autogenous shrinkage	$\epsilon_{ca}(t_c)$	$\mu\epsilon$	29	EN1992-1-1 $\epsilon_{ca}(t_c) = 2.5 (f_{ck} - 10) \times (1 - \exp(-0.2 t_c^{0.5}))$	
Free contraction	$\epsilon_{fr}(t_c)$	$\mu\epsilon$	379	$\epsilon_{fr}(t_c) = T_1 \alpha_c + \epsilon_{ca}$	408
Restrained early-age strain and risk of cracking					
Restraint	R		0.80	Use restraint calculator for walls or adjacent slabs; or historical data	1
Early-age restrained contraction	$\epsilon_{ra}(t_c)$	$\mu\epsilon$	197	$\epsilon_{ra}(t_c) = R_1 K_1 (T_1 \alpha_c + \epsilon_{ca})$	204
Risk of early age cracking	$\epsilon_{ra}(t_c) / \epsilon_{ct,cr}$		2.63	Low risk of early age cracking if $\epsilon_{ra}(t_c) / \epsilon_{ct,cr} < 1$.	3.14
Early-age crack-inducing strain	$\epsilon_{cr}(t_c)$	$\mu\epsilon$	150	$\epsilon_{cr}(t_c) = R_1 K_1 (T_1 \alpha_c + \epsilon_{ca}) - 0.5 \epsilon_{ct,cr}$	172
Long term strain (excluding early-age strain)					
Autogenous shrinkage (residual up to 28 days)	$\delta \epsilon_{ca}(t)$	$\mu\epsilon$	36	$\delta \epsilon_{ca}(t) = \epsilon_{ca}(28) - \epsilon_{ca}(t)$	
Long term temperature change	T_2	$^\circ\text{C}$	20	T_2 and ϵ_{cd} only apply when causing differential contraction or when the sections acting integrally are subject to external restraint.	20
Drying shrinkage	ϵ_{cd}	$\mu\epsilon$	150		130
Long term free contraction	$\epsilon_{fr}(t)$	$\mu\epsilon$	386	$\epsilon_{fr}(t) = \delta \epsilon_{ca} + T_2 \alpha_c + \epsilon_{cd}$	340
Restrained long term strain					
Restraint to long term thermal strains	R_2		0.80	Restraint will reduce as E_a / E_c approaches 1 in the long term	1
Restraint to drying shrinkage	R_3		0.80		1
Long term restrained strain	$\epsilon_{rl}(t)$	$\mu\epsilon$	201	$\epsilon_{rl}(t) = K_1 (R_2 T_2 \alpha_c + R_3 (\delta \epsilon_{ca} + \epsilon_{cd}))$	170
Increase in tensile strain capacity	$\delta \epsilon_{ct}$	$\mu\epsilon$	41	$\delta \epsilon_{ct} = \epsilon_{ct}(28) - \epsilon_{ct}(t)$	65
Long term crack-inducing strain	$\epsilon_{cr}(t)$	$\mu\epsilon$	160	$\epsilon_{cr}(t) = K_1 (R_2 T_2 \alpha_c + R_3 (\delta \epsilon_{ca} + \epsilon_{cd})) - \delta \epsilon_{ct}$	105
Total strain (early-age + long term)					
Free contraction	$\epsilon_{fr}(t_{tot})$	$\mu\epsilon$	765	$\epsilon_{fr}(t_{tot}) = \epsilon_{fr}(t_c) + \epsilon_{fr}(t)$	748
Restrained contraction	$\epsilon_{ra}(t_{tot})$	$\mu\epsilon$	398	$\epsilon_{ra}(t_{tot}) = \epsilon_{ra}(t_c) + \epsilon_{rl}(t)$	374
Crack-inducing strain	$\epsilon_{cr}(t_{tot})$	$\mu\epsilon$	310	$\epsilon_{cr}(t_{tot}) = \epsilon_{cr}(t_c) + \epsilon_{cr}(t)$	277
Reinforcement details					
Bar diameter	ϕ	mm	56.57		16
Bar spacing	s	mm	150		175
Cover	c	mm	40		40
Area of steel per face per m	A_s	mm^2	16756		1149
Cracking initiated at early age strain					
Minimum area of reinforcement $A_{s,min}$					
Steel ratio for early age cracking	f_{ctm} / f_{yk}		0.00487	$f_{ctm} / f_{yk} = \rho_{cr}$	0.0035
Coefficient	k		0.75	$k = 1.0$ for $h \leq 300\text{mm}$; $k = 0.75$ for $h \geq 800\text{mm}$; intermediate values are interpolated	
Coefficient	k_c		1	For pure tension $k_c = 1$	
Surface zone used in calculating $A_{s,min}$	$h_{s,min}$	mm	938	$h_{s,min} = k k_c h/2$	250
Minimum area of steel per face per m	$A_{s,min}$	mm^2	4567	$A_{s,min} = (h_{s,min} \times 1000) (f_{ctm} / f_{yk})$ Highlighted if $A_s < A_{s,min}$	875
Crack spacing and width					
Surface zone defining the effective area of concrete in tension, $A_{ce,eff}$	$h_{ce,eff}$	mm	170.7125	$h_{ce,eff} = 2.5 (c + \phi/2)$ (NOTE: $h_{s,min}$ and $h_{ce,eff}$ are not the same)	250
Steel ratio for estimating crack spacing	$\rho_{p,eff}$		0.09815	$\rho_{p,eff} = A_s / A_{ce,eff} = A_s / (h_{ce,eff} \times 1000)$	0.00480
Coefficient for bond characteristics	k_1		1.14	EN1992-1-1 recommends $k_1 = 0.8$ but provides a factor of 0.7 where good bond cannot be guaranteed. Hence $k_1 = 0.8/0.7 = 1.14$	0.67
Crack spacing	$S_{r,max}$	mm	415	$S_{r,max} = 3.4c + 0.425 k_1 \phi / \rho_{p,eff}$	1168
Early age crack width	w_k	mm	0.06	$w_k = \epsilon_{cr}(t) S_{r,max}$	0.20
Long term crack width	w_k	mm	0.13	$w_k = \epsilon_{cr}(t_{tot}) S_{r,max}$	0.32
Minimum reinforcement requirement for late-life cracking only					
Steel ratio for late-life cracking	f_{ctm} / f_{yk}		0.0081	$f_{ctm} / f_{yk} = \rho_{cr}$	0.0033
Minimum area of steel per face	$A_{s,min}$	mm^2	7634	Highlighted if $A_s < A_{s,min}$	815

Control of cracking due to internal restraint (Roof slab C40 & 24C)				
Input parameters	Symbol	Unit	Value	
Concrete and steel properties				
Section thickness	h	mm	3000	
Strength class	$f_{ck}/f_{ctk,cen}$	MPa	C30/37	
Age at cracking	t_c	days	3	Assume 3 days unless more reliable information is available
Creep factor	K_1		0.65	Default = 0.65
Sustained load factor	K_2		0.80	Default = 0.8
Coefficient of thermal expansion	α_c	$\mu\epsilon/^\circ\text{C}$	19.0	If aggregate is unknown use 12
Characteristic yield strength of reinforcement	f_{ky}	MPa	500	500 MPa (EN1992-1-1)
Early-age concrete properties				
Tensile strength	$f_{ct,eff}$	MPa	1.73	Mean value of tensile strength, $f_{ctm}(t_c)$
Elastic modulus	E_c	GPa	28.1	Mean value of elastic modulus $E_{cm}(t_c)$
Tensile strain capacity under sustained loading	$\epsilon_{ct,s}$	$\mu\epsilon$	76	$\epsilon_{ct,s} = [f_{ctm}(t_c) / E_{cm}(t_c)] \times [K_2 / K_1]$
Early-age strain				
Temperature differential	ΔT	$^\circ\text{C}$	24	$\Delta T = \text{Peak temperature} - \text{surface temperature}$
Free differential strain	$\Delta\epsilon_{free}$	$\mu\epsilon$	240	$\Delta\epsilon_{free} = \Delta T \alpha_c$
Restraint	R		0.42	
Restrained differential strain	$\Delta\epsilon_r$	$\mu\epsilon$	66	$\Delta\epsilon_{restr} = R, K_1 \Delta T \alpha_c$
Risk of early-age cracking	$\Delta\epsilon_r / \epsilon_{ct,s}$		0.86	Low risk of early-age cracking if $\Delta\epsilon_r / \epsilon_{ct,s} < 1$.
Crack-inducing differential strain	$\Delta\epsilon_{cr}$	$\mu\epsilon$	28	$\Delta\epsilon_{cr} = R, K_1 \Delta T \alpha_c - 0.5 \epsilon_{ct,s}$
Reinforcement details				
Bar diameter	φ	mm	56.67	
Bar spacing	S	mm	150	
Cover	c	mm	40	
Area of steel per face per m	A_s	mm^2	16756	
Early-age cracking				
Steel ratio for estimating $A_{s,min}$	f_{ctm}/f_{yk}		0.0035	$f_{ctm}/f_{yk} = \rho_{eff}$
Coefficient	k		1.0	
Coefficient	k_c		0.5	
Surface zone defining the area of concrete in the tensile zone A_{cr}	$h_{z,min}$	mm	600	$h_{z,min} = 0.2 h$
Minimum area of steel per face	$A_{s,min}$	mm^2	1040	Highlighted if $A_s < A_{s,min}$
Surface zone defining the effective area of concrete in tension, $A_{ce,eff}$	$h_{e,eff}$	mm	170.7125	$h_{e,eff} = 2.5(c + \varphi/2)$ [NB $h_{z,min}$ and $h_{e,eff}$ are not the same]
Steel ratio for calculating early-age crack spacing	$\rho_{R,eff}$		0.09815	$\rho_{R,eff} = A_s / A_{ce,eff} = A_s / (h_{e,eff} \times 1000)$
Coefficient for bond characteristics	k_1		1.14	
Crack spacing	$s_{r,max}$	mm	416	$s_{r,max} = 3.4 c + 0.425 k_1 \varphi / \rho_{R,eff}$
Crack width	w_k	mm	0.01	$w_k = \Delta\epsilon_{cr} s_{r,max}$

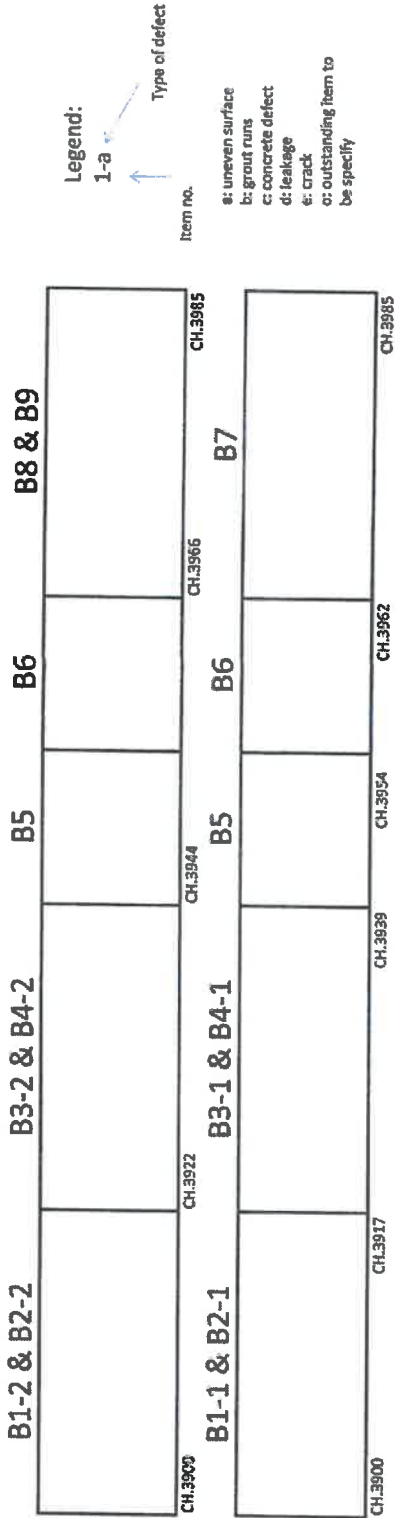
Risk and control of cracking due to continuous edge restraint (Roof slab C40 & 24C)					
Input parameters	Symbol	Unit	Value		CIRIA 81 BS8007
Section details and material properties					
Section thickness	h	mm	3000		500
Strength class	$f_{ck} / f_{ck,cube}$	MPa	C30/37		
Age at cracking	t_c	days	3	Assume 3 days unless more reliable information is available	
Creep factor	K_1		0.65	$K_1 = 0.65$ if R is calculated; $K_1 = 1$ if R is assumed to be 0.5 (including creep to EN1992-1-1)	0.5
Sustained load factor	K_2		0.80		
Coefficient of thermal expansion of concrete	α_c	$\mu\epsilon/^\circ C$	10.0	If aggregate is unknown use $12 \mu\epsilon / ^\circ C$	12
Characteristic yield strength of reinforcement	f_{yk}	MPa	500	500 Mpa	450
Early age concrete properties					
Tensile strength at cracking	$f_{ctm}(t_c)$	MPa	1.73	Mean value of tensile strength $f_{ctm}(t_c)$	1.61
Elastic modulus	$E_{cm}(t_c)$	GPa	28.1	Mean value of elastic modulus $E_{cm}(t_c)$	
Tensile strain capacity	$\epsilon_{ct,tes}$	$\mu\epsilon$	76	$\epsilon_{ct,tes} = [f_{ctm}(t_c) / E_{cm}(t_c)] \times [K_2 / K_1]$	65
Long term concrete properties					
Tensile strength	f_{ctm}	MPa	2.60	Mean 28-day value	
Elastic modulus	E_{cm}	GPa	32.8	Mean 28-day value	
Tensile strain capacity (sustained loading)	$\epsilon_{ct,st}$	$\mu\epsilon$	109	$\epsilon_{ct,st} = [f_{ctm} / E_{cm}] \times [K_2 / K_1]$	130
Early-age strain					
Temperature drop	T_1	$^\circ C$	24	T_1 = Peak temperature - mean ambient temperature	34
Autogenous shrinkage	$\epsilon_{ca}(t_c)$	$\mu\epsilon$	15	EN1992-1-1 $\epsilon_{ca}(t_c) = 2.5 (f_{ck} - 10) \times (1 - \exp(-0.2 t_c^{0.5}))$	
Free contraction	$\epsilon_{free}(t_c)$	$\mu\epsilon$	255	$\epsilon_{free}(t_c) = T_1 \alpha_c + \epsilon_{ca}$	408
Restrained early-age strain and risk of cracking					
Restraint	R		0.80	Use restraint calculator for walls or adjacent slabs; or historical data	1
Early-age restrained contraction	$\epsilon_{ra}(t_c)$	$\mu\epsilon$	132	$\epsilon_{ra}(t_c) = R_1 K_1 (T_1 \alpha_c + \epsilon_{ca})$	204
Risk of early age cracking	$\epsilon_{ra}(t_c) / \epsilon_{ct,tes}$		2.18	Low risk of early age cracking if $\epsilon_{ra}(t_c) / \epsilon_{ct,tes} < 1$.	3.14
Early-age crack-inducing strain	$\epsilon_{cr}(t_c)$	$\mu\epsilon$	95	$\epsilon_{cr}(t_c) = R_1 K_1 (T_1 \alpha_c + \epsilon_{ca}) - 0.5 \epsilon_{ct,tes}$	172
Long term strain (excluding early-age strain)					
Autogenous shrinkage (residual up to 28 days)	$\delta\epsilon_{ca}(t_c)$	$\mu\epsilon$	18	$\delta\epsilon_{ca}(t_c) = \epsilon_{ca}(28) - \epsilon_{ca}(t_c)$	
Long term temperature change	T_2	$^\circ C$	20	T_2 and ϵ_{ed} only apply when causing differential contraction or when the sections acting integrally are subject to external restraint.	20
Drying shrinkage	ϵ_{ed}	$\mu\epsilon$	180		100
Long term free contraction	$\epsilon_{free}(t_c)$	$\mu\epsilon$	366	$\epsilon_{free}(t_c) = \delta\epsilon_{ca} + T_2 \alpha_c + \epsilon_{ed}$	340
Restrained long term strain					
Restraint to long term thermal strains	R_2		0.80	Restraint will reduce as E_n / E_o approaches 1 in the long term	1
Restraint to drying shrinkage	R_3		0.80		1
Long term restrained strain	$\epsilon_{ra}(t_c)$	$\mu\epsilon$	191	$\epsilon_{ra}(t_c) = K_1 (R_2 T_2 \alpha_c + R_3 (\delta\epsilon_{ca} + \epsilon_{ed}))$	170
Increase in tensile strain capacity	$\delta\epsilon_{ct,tes}$	$\mu\epsilon$	33	$\delta\epsilon_{ct,tes} = \epsilon_{ct,tes}(t_c) - \epsilon_{ct,tes}(28)$	65
Long term crack-inducing strain	$\epsilon_{cr}(t_c)$	$\mu\epsilon$	159	$\epsilon_{cr}(t_c) = K_1 (R_2 T_2 \alpha_c + R_3 (\delta\epsilon_{ca} + \epsilon_{ed})) - \delta\epsilon_{ct,tes}$	105
Total strain (early-age + long term)					
Free contraction	$\epsilon_{free}(t_c)$	$\mu\epsilon$	623	$\epsilon_{free}(t_c) = \epsilon_{free}(t_c) + \epsilon_{free}(t_c)$	748
Restrained contraction	$\epsilon_{ra}(t_c)$	$\mu\epsilon$	324	$\epsilon_{ra}(t_c) = \epsilon_{ra}(t_c) + \epsilon_{ra}(t_c)$	374
Crack-inducing strain	$\epsilon_{cr}(t_c)$	$\mu\epsilon$	253	$\epsilon_{cr}(t_c) = \epsilon_{cr}(t_c) + \epsilon_{cr}(t_c)$	277
Reinforcement details					
Bar diameter	ϕ	mm	56.57		16
Bar spacing	s	mm	150		175
Cover	c	mm	40		40
Area of steel per face per m	A_s	mm^2	16756		1149
Cracking initiated at early age strain					
Minimum area of reinforcement $A_{s,min}$					
Steel ratio for early age cracking	f_{ctm} / f_{yk}		0.00347	$f_{ctm} / f_{yk} = \rho_{cr}$	0.0035
Coefficient	k		0.75	$k = 1.0$ for $h \leq 300$ mm; $k = 0.75$ for $h \geq 800$ mm; intermediate values are interpolated	
Coefficient	k_c		1	For pure tension $k_c = 1$	
Surface zone used in calculating $A_{s,min}$	$h_{s,min}$	mm	1125	$h_{s,min} = k k_c h/2$	250
Minimum area of steel per face per m	$A_{s,min}$	mm^2	3899	$A_{s,min} = (h_{s,min} \times 1000) (f_{ctm} / f_{yk})$ Highlighted if $A_s < A_{s,min}$	875
Crack spacing and width					
Surface zone defining the effective area of concrete in tension, $A_{c,eff}$	$h_{e,eff}$	mm	170.7125	$h_{e,eff} = 2.5 (c + \phi/2)$ [NOTE: $h_{s,min}$ and $h_{e,eff}$ are not the same]	250
Steel ratio for estimating crack spacing	$\rho_{p,eff}$		0.09815	$\rho_{p,eff} = A_s / A_{c,eff} = A_s / (h_{e,eff} \times 1000)$	0.00460
Coefficient for bond characteristics	k_1		1.34	EN1992-1-1 recommends $k_1 = 0.8$ but provides a factor of 0.7 where good bond cannot be guaranteed. Hence $k_1 = 0.8/0.7 = 1.14$	0.67
Crack spacing	$S_{r,max}$	mm	415	$S_{r,max} = 3.4c + 0.425 k_1 \phi / \rho_{p,eff}$	1168
Early age crack width	w_k	mm	0.04	$w_k = \epsilon_{cr}(t_c) S_{r,max}$	0.20
Long term crack width	w_k	mm	0.11	$w_k = \epsilon_{cr}(t_c) S_{r,max}$	0.32
Minimum reinforcement requirement for late-life cracking only					
Steel ratio for late-life cracking	f_{ctm} / f_{yk}		0.0058	$f_{ctm} / f_{yk} = \rho_{cr}$	0.0033
Minimum area of steel per face	$A_{s,min}$	mm^2	6517	Highlighted if $A_s < A_{s,min}$	815

Control of cracking due to internal restraint (Roof slab C60 & 32.3C)				
Input parameters	Symbol	Unit	Value	
Concrete and steel properties				
Section thickness	h	mm	3000	
Strength class	$f_{ctk}/f_{ct,cube}$	MPa	C50/60	
Age at cracking	t_p	days	3	Assume 3 days unless more reliable information is available
Creep factor	K_1		0.65	Default = 0.65
Sustained load factor	K_2		0.80	Default = 0.8
Coefficient of thermal expansion	α_c	$\mu\epsilon/^\circ\text{C}$	10.0	If aggregate is unknown use 12
Characteristic yield strength of reinforcement	f_{yk}	MPa	500	500 MPa (EN1992-1-1)
Early-age concrete properties				
Tensile strength	$f_{ct,eff}$	MPa	2.44	Mean value of tensile strength, $f_{ctm}(t_a)$
Elastic modulus	E_c	GPa	32.0	Mean value of elastic modulus $E_{cm}(t_c)$
Tensile strain capacity under sustained loading	$\epsilon_{ct,s}$	$\mu\epsilon$	94	$\epsilon_{ct,s} = [f_{ctm}(t_c) / E_{cm}(t_c)] \times [K_2 / K_1]$
Early-age strain				
Temperature differential	ΔT	$^\circ\text{C}$	32.3	$\Delta T = \text{Peak temperature} - \text{surface temperature}$
Free differential strain	$\Delta\epsilon_{free}$	$\mu\epsilon$	323	$\Delta\epsilon_{free} = \Delta T \alpha_c$
Restraint	R		0.42	
Restrained differential strain	$\Delta\epsilon_r$	$\mu\epsilon$	88	$\Delta\epsilon_{r(ea)} = R, K_1 \Delta T \alpha_c$
Risk of early-age cracking	$\Delta\epsilon_r / \epsilon_{ct,s}$		0.94	Low risk of early-age cracking if $\Delta\epsilon_r / \epsilon_{ct,s} < 1$.
Crack-inducing differential strain	$\Delta\epsilon_{cr}$	$\mu\epsilon$	41	$\Delta\epsilon_{cr} = R, K_1 \Delta T \alpha_c - 0.5 \epsilon_{ct,s}$
Reinforcement details				
Bar diameter	ϕ	mm	56.57	
Bar spacing	S	mm	150	
Cover	c	mm	40	
Area of steel per face per m	A_s	mm^2	16756	
Early-age cracking				
Steel ratio for estimating $A_{s,min}$	f_{ctm}/f_{yk}		0.0049	$f_{ctm}/f_{yk} = \rho_{min}$
Coefficient	k		1.0	
Coefficient	k_c		0.5	
Surface zone defining the area of concrete in the tensile zone A_{st}	$h_{e,min}$	mm	600	$h_{e,min} = 0.2 h$
Minimum area of steel per face	$A_{s,min}$	mm^2	1461	Highlighted if $A_s < A_{s,min}$
Surface zone defining the effective area of concrete in tension, $A_{e,eff}$	$h_{e,eff}$	mm	170.7125	$h_{e,eff} = 2.5 (c + \phi/2)$ [NB $h_{e,min}$ and $h_{e,eff}$ are not the same]
Steel ratio for calculating early-age crack spacing	$\rho_{p,eff}$		0.03815	$\rho_{p,eff} = A_s / A_{e,eff} = A_s / (h_{e,eff} \times 1000)$
Coefficient for bond characteristics	k_f		1.14	
Crack spacing	$s_{r,max}$	mm	415	$s_{r,max} = 3.4 c + 0.425 k_f \phi / \rho_{p,eff}$
Crack width	w_k	mm	0.02	$w_k = \Delta\epsilon_{cr} s_{r,max}$

Risk and control of cracking due to continuous edge restraint (Roof slab C60 & 32.3C)					
Input parameters	Symbol	Unit	Value		CIRIA 91 BS9007
Section details and material properties					
Section thickness	h	mm	3000		
Strength class	$f_{ck} / f_{ck,cube}$	MPa	C50/60		500
Age at cracking	t_c	days	3	Assume 3 days unless more reliable information is available $K_1 = 0.65$ if R is calculated; $K_1 = 1$ if R is assumed to be 0.5 (including creep to EN1992-1-1)	0.5
Creep factor	K_1		0.65		
Sustained load factor	K_2		0.80		
Coefficient of thermal expansion of concrete	α_c	$\mu\epsilon/^\circ\text{C}$	10.0	If aggregate is unknown use $12 \mu\epsilon / ^\circ\text{C}$	
Characteristic yield strength of reinforcement	f_{yk}	MPa	500		500 Mpa
Early age concrete properties					
Tensile strength at cracking	$f_{ctm}(t_c)$	MPa	2.44	Mean value of tensile strength $f_{ctm}(t_c)$	1.61
Elastic modulus	$E_{cm}(t_c)$	GPa	32.0	Mean value of elastic modulus $E_{cm}(t_c)$	
Tensile strain capacity	$\epsilon_{ct,sm}(t_c)$	$\mu\epsilon$	94	$\epsilon_{ct,sm}(t_c) = [f_{ctm}(t_c) / E_{cm}(t_c)] \times [K_2 / K_1]$	65
Long term concrete properties					
Tensile strength	f_{ctm}	MPa	4.07	Mean 28-day value	
Elastic modulus	E_{cm}	GPa	37.3	Mean 28-day value	
Tensile strain capacity (sustained loading)	$\epsilon_{ct,s}(t)$	$\mu\epsilon$	134	$\epsilon_{ct,s}(t) = [f_{ctm} / E_{cm}] \times [K_2 / K_1]$	130
Early-age strain					
Temperature drop	T_1	$^\circ\text{C}$	32.3	$T_1 = \text{Peak temperature} - \text{mean ambient temperature}$	
Autogenous shrinkage	$\epsilon_{ca}(t_c)$	$\mu\epsilon$	29	EN1992-1-1 $\epsilon_{ca}(t_c) = 2.5 (f_{ck} - 10) \times (1 - \exp(-0.2 t_c^{0.5}))$	24
Free contraction	$\epsilon_{cs}(t_c)$	$\mu\epsilon$	352	$\epsilon_{cs}(t_c) = T_1 \alpha_c + \epsilon_{ca}$	408
Restrained early-age strain and risk of cracking					
Restraint	R		0.80	Use restraint calculator for walls or adjacent slabs; or historical data	1
Early-age restrained contraction	$\epsilon_{ra}(t_c)$	$\mu\epsilon$	183	$\epsilon_{ra}(t_c) = R_1 K_1 (T_1 \alpha_c + \epsilon_{ca})$	204
Risk of early age cracking	$\epsilon_{ra}(t_c) / \epsilon_{ct,s}$		2.44	Low risk of early age cracking if $\epsilon_{ra}(t_c) / \epsilon_{ct,s} < 1$.	3.14
Early-age crack-inducing strain	$\epsilon_{ct,ra}(t_c)$	$\mu\epsilon$	136	$\epsilon_{ct,ra}(t_c) = R_1 K_1 (T_1 \alpha_c + \epsilon_{ca}) - 0.5 \epsilon_{ct,s}$	172
Long term strain (excluding early-age strain)					
Autogenous shrinkage (residual up to 28 days)	$\delta\epsilon_{ca}(t)$	$\mu\epsilon$	36	$\delta\epsilon_{ca}(t) = \epsilon_{ca}(t) - \epsilon_{ca}(t_c)$	
Long term temperature change	T_2	$^\circ\text{C}$	20	T_2 and ϵ_{cd} only apply when causing differential contraction or when the sections acting integrally are subject to external restraint.	20
Drying shrinkage	ϵ_{cd}	$\mu\epsilon$	150		190
Long term free contraction	$\epsilon_{cs}(t)$	$\mu\epsilon$	386	$\epsilon_{cs}(t) = \delta\epsilon_{ca} + T_2 \alpha_c + \epsilon_{cd}$	340
Restrained long term strain					
Restraint to long term thermal strains	R_2		0.80	Restraint will reduce as E_n / E_o approaches 1 in the long term	1
Restraint to drying shrinkage	R_3		0.80		1
Long term restrained strain	$\epsilon_{rl}(t)$	$\mu\epsilon$	201	$\epsilon_{rl}(t) = K_1 (R_2 T_2 \alpha_c + R_3 (\delta\epsilon_{ca} + \epsilon_{cd}))$	170
Increase in tensile strain capacity	$\delta\epsilon_{ct,s}$	$\mu\epsilon$	41	$\delta\epsilon_{ct,s} = \epsilon_{ct,s}(t) - \epsilon_{ct,s}(t_c)$	65
Long term crack-inducing strain	$\epsilon_{ct,rl}(t)$	$\mu\epsilon$	160	$\epsilon_{ct,rl}(t) = K_1 (R_2 T_2 \alpha_c + R_3 (\delta\epsilon_{ca} + \epsilon_{cd})) - \delta\epsilon_{ct,s}$	105
Total strain (early-age + long term)					
Free contraction	$\epsilon_{cs}(t)$	$\mu\epsilon$	738	$\epsilon_{cs}(t) = \epsilon_{ca}(t) + \epsilon_{cd}$	748
Restrained contraction	$\epsilon_{ra}(t)$	$\mu\epsilon$	384	$\epsilon_{ra}(t) = \epsilon_{ra}(t_c) + \epsilon_{rl}(t)$	374
Crack-inducing strain	$\epsilon_{ct,ra}(t)$	$\mu\epsilon$	296	$\epsilon_{ct,ra}(t) = \epsilon_{ct,ra}(t_c) + \epsilon_{ct,rl}(t)$	277
Reinforcement details					
Bar diameter	ϕ	mm	58.57		
Bar spacing	s	mm	150		1E
Cover	c	mm	40		17.5
Area of steel per face per m	A_s	mm^2	16756		40
Cracking initiated at early age strain					
Minimum area of reinforcement $A_{s,min}$					
Steel ratio for early age cracking	f_{ctm} / f_{yk}		0.00487	$f_{ctm} / f_{yk} = \rho_{cr}$	0.0035
Coefficient	k		0.75	$k = 1.0$ for $h \leq 300\text{mm}$; $k = 0.75$ for $h \geq 800\text{mm}$; intermediate values are interpolated	
Coefficient	k_c		1	For pure tension $k_c = 1$	
Surface zone used in calculating $A_{s,min}$	$h_{s,min}$	mm	1125	$h_{s,min} = k_c h / 2$	250
Minimum area of steel per face per m	$A_{s,min}$	mm^2	5481	$A_{s,min} = (h_{s,min} \times 1000) (f_{ctm} / f_{yk})$ Highlighted if $A_s < A_{s,min}$	875
Crack spacing and width					
Surface zone defining the effective area of concrete in tension, $A_{c,eff}$	$h_{s,eff}$	mm	170.7125	$h_{s,eff} = 2.5 (c + \phi/2)$ [NOTE: $h_{s,min}$ and $h_{s,eff}$ are not the same]	250
Steel ratio for estimating crack spacing	$\rho_{s,eff}$		0.09915	$\rho_{s,eff} = A_s / A_{c,eff} = A_s / (h_{s,eff} \times 1000)$	0.00460
Coefficient for bond characteristics	k_1		1.14	EN1992-1-1 recommends $k_1 = 0.8$ but provides a factor of 0.7 where good bond cannot be guaranteed. Hence $k_1 = 0.8/0.7 = 1.14$	0.67
Crack spacing	$S_{r,max}$	mm	415	$S_{r,max} = 3.4c + 0.425 k_1 \phi / \rho_{s,eff}$	1166
Early age crack width	w_k	mm	0.06	$w_k = \epsilon_{ct,ra}(t_c) S_{r,max}$	0.20
Long term crack width	w_k	mm	0.12	$w_k = \epsilon_{ct,ra}(t) S_{r,max}$	0.32
Minimum reinforcement requirement for late-life cracking only					
Steel ratio for late-life cracking	f_{ctm} / f_{yk}		0.0081	$f_{ctm} / f_{yk} = \rho_{cr}$	0.0033
Minimum area of steel per face	$A_{s,min}$	mm^2	9161	Highlighted if $A_s < A_{s,min}$	815

Location of Concrete Crack at TCPWAE tunnel base slab

Update : 15/1/2016



Item No.	Location								Item No. B8 & B9	Remark
	B1-2 & B2-2	B1-1 & B2-1	B3-2 & B4-2	B3-1 & B4-1	B5	B6	B7	B8 & B9		
Crack length (m)										All of the crack width < 0.25mm
sub total length (m):	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Inspected By: _____

Witnessed By: _____

Location of Concrete Crack at TCPWAE tunnel roof slab

Update : 15/1/2016

East Bound (Roof)

T1	T2	T3	T4	T5	T6	T7 & T8	T9 & T10	T11 & 12	
CH.3900	CH.3910	CH.3918	CH.3926	CH.3934	CH.3942	CH.3950	CH.3962	CH.3976	CH.3985

	Waiting for repair		Concrete defect
	Grouted		OHVD
	Make good		
	New Crack		

Item No.	Location												Remark	
	T1	T2	T3	T4	T5	T6	T8	T9	T12					
Crack length (m)														All of the crack width < 0.25mm
sub total length (m):	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Inspected By: 

Witnessed By: 

Roof slab : T1

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1175099	10-Jul-13	7-Aug-13	61.5
2	CA1175114	10-Jul-13	7-Aug-13	64.5
3	CA1175117	10-Jul-13	7-Aug-13	63.5
4	CA1175120	10-Jul-13	7-Aug-13	64.5
5	CA1175129	10-Jul-13	7-Aug-13	70.5
6	CA1175144	10-Jul-13	7-Aug-13	71.5
7	CA1175408	10-Jul-13	7-Aug-13	65.5
8	CA1175425	10-Jul-13	7-Aug-13	59.5
9	CA1175195	10-Jul-13	7-Aug-13	65.5
10	CA1175198	10-Jul-13	7-Aug-13	65.5
11	CA1175405	10-Jul-13	7-Aug-13	65.5
12	CA1175180	10-Jul-13	7-Aug-13	65.5
13	CA1175183	10-Jul-13	7-Aug-13	65.5
14	CA1175186	10-Jul-13	7-Aug-13	66.0
15	CA1175153	10-Jul-13	7-Aug-13	68.5
16	CA1175159	10-Jul-13	7-Aug-13	63.5
17	CA1175174	10-Jul-13	7-Aug-13	64.5
18	CA1175100	10-Jul-13	7-Aug-13	62.5
19	CA1175115	10-Jul-13	7-Aug-13	63.5
20	CA1175118	10-Jul-13	7-Aug-13	62.5
21	CA1175121	10-Jul-13	7-Aug-13	66.5
22	CA1175130	10-Jul-13	7-Aug-13	70.5
23	CA1175145	10-Jul-13	7-Aug-13	72.5
24	CA1175409	10-Jul-13	7-Aug-13	66.5
25	CA1175426	10-Jul-13	7-Aug-13	58.5
26	CA1175196	10-Jul-13	7-Aug-13	67.0
27	CA1175199	10-Jul-13	7-Aug-13	69.0
28	CA1175406	10-Jul-13	7-Aug-13	63.5
29	CA1175181	10-Jul-13	7-Aug-13	62.0
30	CA1175184	10-Jul-13	7-Aug-13	69.0
31	CA1175187	10-Jul-13	7-Aug-13	63.0
32	CA1175154	10-Jul-13	7-Aug-13	67.5
33	CA1175160	10-Jul-13	7-Aug-13	66.5
34	CA1175175	10-Jul-13	7-Aug-13	62.5

Roof slab : T2

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1233381	3-Jun-13	1-Jul-13	71.0
2	CA1233382	3-Jun-13	1-Jul-13	68.5
3	CA1233387	3-Jun-13	1-Jul-13	65.5
4	CA1233388	3-Jun-13	1-Jul-13	62.0
5	CA1233393	3-Jun-13	1-Jul-13	66.5
6	CA1233394	3-Jun-13	1-Jul-13	64.0
7	CA1233372	3-Jun-13	1-Jul-13	67.0
8	CA1233373	3-Jun-13	1-Jul-13	59.5
9	CA1233375	3-Jun-13	1-Jul-13	56.5
10	CA1233376	3-Jun-13	1-Jul-13	61.5
11	CA1233378	3-Jun-13	1-Jul-13	70.0
12	CA1233379	3-Jun-13	1-Jul-13	66.5
13	CA1233357	3-Jun-13	1-Jul-13	70.0
14	CA1233358	3-Jun-13	1-Jul-13	65.5
15	CA1233366	3-Jun-13	1-Jul-13	69.0
16	CA1233367	3-Jun-13	1-Jul-13	65.5
17	CA1233369	3-Jun-13	1-Jul-13	67.0
18	CA1233370	3-Jun-13	1-Jul-13	67.0
19	CA1233348	3-Jun-13	1-Jul-13	68.0
20	CA1233349	3-Jun-13	1-Jul-13	69.0
21	CA1233351	3-Jun-13	1-Jul-13	67.5
22	CA1233352	3-Jun-13	1-Jul-13	67.5
23	CA1233354	3-Jun-13	1-Jul-13	69.0
24	CA1233355	3-Jun-13	1-Jul-13	68.5
25	CA1233327	3-Jun-13	1-Jul-13	73.5
26	CA1233328	3-Jun-13	1-Jul-13	75.5
27	CA1233330	3-Jun-13	1-Jul-13	73.5
28	CA1233331	3-Jun-13	1-Jul-13	75.0
29	CA1233333	3-Jun-13	1-Jul-13	70.0
30	CA1233334	3-Jun-13	1-Jul-13	69.0
31	CA1233315	3-Jun-13	1-Jul-13	70.5
32	CA1233316	3-Jun-13	1-Jul-13	73.5
33	CA1233321	3-Jun-13	1-Jul-13	75.0
34	CA1233322	3-Jun-13	1-Jul-13	70.5
35	CA1233324	3-Jun-13	1-Jul-13	69.0
36	CA1233325	3-Jun-13	1-Jul-13	74.0
37	CA1233294	3-Jun-13	1-Jul-13	67.0
38	CA1233295	3-Jun-13	1-Jul-13	66.0
39	CA1233303	3-Jun-13	1-Jul-13	67.0
40	CA1233304	3-Jun-13	1-Jul-13	66.5
41	CA1233306	3-Jun-13	1-Jul-13	67.0
42	CA1233307	3-Jun-13	1-Jul-13	71.0
43	CA1233285	3-Jun-13	1-Jul-13	70.5
44	CA1233286	3-Jun-13	1-Jul-13	65.5

45	CA1233288	3-Jun-13	1-Jul-13	66.0
46	CA1233289	3-Jun-13	1-Jul-13	65.5
47	CA1233291	3-Jun-13	1-Jul-13	65.5
48	CA1233292	3-Jun-13	1-Jul-13	67.5
49	CA1233270	3-Jun-13	1-Jul-13	63.0
50	CA1233271	3-Jun-13	1-Jul-13	65.0
51	CA1233273	3-Jun-13	1-Jul-13	63.0
52	CA1233274	3-Jun-13	1-Jul-13	68.5
53	CA1233282	3-Jun-13	1-Jul-13	67.5
54	CA1233283	3-Jun-13	1-Jul-13	65.5
55	CA1233197	3-Jun-13	1-Jul-13	68.0
56	CA1233198	3-Jun-13	1-Jul-13	67.5
57	CA1233200	3-Jun-13	1-Jul-13	68.5
58	CA1233265	3-Jun-13	1-Jul-13	63.5
59	CA1233267	3-Jun-13	1-Jul-13	63.0
60	CA1233268	3-Jun-13	1-Jul-13	63.5
61	CA1233300	3-Jun-13	1-Jul-13	70.0
62	CA1233301	3-Jun-13	1-Jul-13	66.5
63	CA1233339	3-Jun-13	1-Jul-13	73.0
64	CA1233340	3-Jun-13	1-Jul-13	73.5
65	CA1233360	3-Jun-13	1-Jul-13	68.5
66	CA1233361	3-Jun-13	1-Jul-13	70.0
67	CA1233342	3-Jun-13	1-Jul-13	71.5
68	CA1233343	3-Jun-13	1-Jul-13	69.0
69	CA1233384	3-Jun-13	1-Jul-13	63.0
70	CA1233385	3-Jun-13	1-Jul-13	65.5
71	CA1233390	3-Jun-13	1-Jul-13	68.0
72	CA1233391	3-Jun-13	1-Jul-13	67.0
73	CA1233276	3-Jun-13	1-Jul-13	67.0
74	CA1233277	3-Jun-13	1-Jul-13	68.0
75	CA1233279	3-Jun-13	1-Jul-13	66.0
76	CA1233280	3-Jun-13	1-Jul-13	65.0
77	CA1233297	3-Jun-13	1-Jul-13	62.5
78	CA1233298	3-Jun-13	1-Jul-13	66.5

Roof slab : T3

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1233038	6-May-13	3-Jun-13	76.0
2	CA1233039	6-May-13	3-Jun-13	75.0
3	CA1233041	6-May-13	3-Jun-13	73.0
4	CA1233042	6-May-13	3-Jun-13	71.5
5	CA1233045	6-May-13	3-Jun-13	76.0
6	CA1233044	6-May-13	3-Jun-13	71.0
7	CA1233077	6-May-13	3-Jun-13	70.5
8	CA1233078	6-May-13	3-Jun-13	71.5
9	CA1233083	6-May-13	3-Jun-13	71.5
10	CA1233084	6-May-13	3-Jun-13	72.5
11	CA1233086	6-May-13	3-Jun-13	65.0
12	CA1233087	6-May-13	3-Jun-13	67.0
13	CA1233050	6-May-13	3-Jun-13	64.5
14	CA1233051	6-May-13	3-Jun-13	67.0
15	CA1233059	6-May-13	3-Jun-13	66.0
16	CA1233060	6-May-13	3-Jun-13	66.5
17	CA1233062	6-May-13	3-Jun-13	66.5
18	CA1233063	6-May-13	3-Jun-13	66.0
19	CA1233107	6-May-13	3-Jun-13	67.0
20	CA1233108	6-May-13	3-Jun-13	65.5
21	CA1233110	6-May-13	3-Jun-13	65.0
22	CA1233111	6-May-13	3-Jun-13	64.5
23	CA1233119	6-May-13	3-Jun-13	68.0
24	CA1233120	6-May-13	3-Jun-13	64.5
25	CA1233011	6-May-13	3-Jun-13	66.5
26	CA1233012	6-May-13	3-Jun-13	70.0
27	CA1233014	6-May-13	3-Jun-13	67.5
28	CA1233015	6-May-13	3-Jun-13	67.5
29	CA1233017	6-May-13	3-Jun-13	63.0
30	CA1233018	6-May-13	3-Jun-13	64.0
31	CA1233020	6-May-13	3-Jun-13	65.0
32	CA1233021	6-May-13	3-Jun-13	66.0
33	CA1233032	6-May-13	3-Jun-13	77.5
34	CA1233033	6-May-13	3-Jun-13	77.0
35	CA1233035	6-May-13	3-Jun-13	72.5
36	CA1233036	6-May-13	3-Jun-13	78.0
37	CA1233068	6-May-13	3-Jun-13	69.0
38	CA1233069	6-May-13	3-Jun-13	65.5
39	CA1233071	6-May-13	3-Jun-13	66.0
40	CA1233072	6-May-13	3-Jun-13	67.0
41	CA1233074	6-May-13	3-Jun-13	68.0
42	CA1233075	6-May-13	3-Jun-13	70.0
43	CA1233092	6-May-13	3-Jun-13	61.5
44	CA1233093	6-May-13	3-Jun-13	65.0

45	CA1233101	6-May-13	3-Jun-13	66.0
46	CA1233102	6-May-13	3-Jun-13	67.5
47	CA1233104	6-May-13	3-Jun-13	63.5
48	CA1233105	6-May-13	3-Jun-13	66.0
49	CA1233125	6-May-13	3-Jun-13	74.5
50	CA1233126	6-May-13	3-Jun-13	74.5
51	CA1233128	6-May-13	3-Jun-13	74.5
52	CA1233129	6-May-13	3-Jun-13	74.0
53	CA1233137	6-May-13	3-Jun-13	64.5
54	CA1233138	6-May-13	3-Jun-13	59.0
55	CA1233023	6-May-13	3-Jun-13	70.0
56	CA1233024	6-May-13	3-Jun-13	67.0
57	CA1233026	6-May-13	3-Jun-13	75.5
58	CA1233027	6-May-13	3-Jun-13	71.0
59	CA1233029	6-May-13	3-Jun-13	75.0
60	CA1233030	6-May-13	3-Jun-13	75.5
61	CA1233002	6-May-13	3-Jun-13	65.0
62	CA1233003	6-May-13	3-Jun-13	66.0
63	CA1233005	6-May-13	3-Jun-13	66.5
64	CA1233006	6-May-13	3-Jun-13	66.5
65	CA1233008	6-May-13	3-Jun-13	64.5
66	CA1233009	6-May-13	3-Jun-13	67.5
67	CA1233134	6-May-13	3-Jun-13	61.0
68	CA1233135	6-May-13	3-Jun-13	62.0
69	CA1233140	6-May-13	3-Jun-13	67.5
70	CA1233141	6-May-13	3-Jun-13	60.5
71	CA1233143	6-May-13	3-Jun-13	69.5
72	CA1233144	6-May-13	3-Jun-13	65.0
73	CA1233116	6-May-13	3-Jun-13	65.5
74	CA1233117	6-May-13	3-Jun-13	65.0
75	CA1233122	6-May-13	3-Jun-13	65.0
76	CA1233123	6-May-13	3-Jun-13	63.5
77	CA1233131	6-May-13	3-Jun-13	77.0
78	CA1233132	6-May-13	3-Jun-13	76.0
79	CA1233095	6-May-13	3-Jun-13	66.5
80	CA1233096	6-May-13	3-Jun-13	67.5
81	CA1233098	6-May-13	3-Jun-13	65.5
82	CA1233099	6-May-13	3-Jun-13	65.0
83	CA1233113	6-May-13	3-Jun-13	63.5
84	CA1233114	6-May-13	3-Jun-13	61.5
85	CA1233065	6-May-13	3-Jun-13	69.5
86	CA1233066	6-May-13	3-Jun-13	69.0
87	CA1233080	6-May-13	3-Jun-13	72.5
88	CA1233081	6-May-13	3-Jun-13	71.0
89	CA1233089	6-May-13	3-Jun-13	68.0
90	CA1233090	6-May-13	3-Jun-13	68.5

91	CA1233047	6-May-13	3-Jun-13	74.0
92	CA1233048	6-May-13	3-Jun-13	71.5
93	CA1233053	6-May-13	3-Jun-13	66.0
94	CA1233054	6-May-13	3-Jun-13	67.0
95	CA1233056	6-May-13	3-Jun-13	67.0
96	CA1233057	6-May-13	3-Jun-13	67.0

Roof slab : T4

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1233922	21-May-13	18-Jun-13	64.5
2	CA1233923	21-May-13	18-Jun-13	62.5
3	CA1233925	21-May-13	18-Jun-13	62.0
4	CA1233926	21-May-13	18-Jun-13	62.5
5	CA1233928	21-May-13	18-Jun-13	61.0
6	CA1233929	21-May-13	18-Jun-13	63.0
7	CA1233931	21-May-13	18-Jun-13	57.5
8	CA1233932	21-May-13	18-Jun-13	64.0
9	CA1233934	21-May-13	18-Jun-13	59.0
10	CA1233935	21-May-13	18-Jun-13	60.5
11	CA1233937	21-May-13	18-Jun-13	69.0
12	CA1233938	21-May-13	18-Jun-13	65.5
13	CA1233955	21-May-13	18-Jun-13	74.0
14	CA1233956	21-May-13	18-Jun-13	71.5
15	CA1233958	21-May-13	18-Jun-13	69.0
16	CA1233959	21-May-13	18-Jun-13	69.5
17	CA1233967	21-May-13	18-Jun-13	71.5
18	CA1233968	21-May-13	18-Jun-13	70.5
19	CA1233940	21-May-13	18-Jun-13	69.0
20	CA1233941	21-May-13	18-Jun-13	69.5
21	CA1233943	21-May-13	18-Jun-13	71.5
22	CA1233944	21-May-13	18-Jun-13	71.0
23	CA1233952	21-May-13	18-Jun-13	71.5
24	CA1233953	21-May-13	18-Jun-13	71.5
25	CA1233230	21-May-13	18-Jun-13	76.0
26	CA1233231	21-May-13	18-Jun-13	75.5
27	CA1233236	21-May-13	18-Jun-13	76.5
28	CA1233237	21-May-13	18-Jun-13	72.0
29	CA1233245	21-May-13	18-Jun-13	76.0
30	CA1233246	21-May-13	18-Jun-13	77.0
31	CA1233215	21-May-13	18-Jun-13	82.5
32	CA1233216	21-May-13	18-Jun-13	78.0
33	CA1233221	21-May-13	18-Jun-13	76.5
34	CA1233222	21-May-13	18-Jun-13	75.0
35	CA1233227	21-May-13	18-Jun-13	72.5
36	CA1233228	21-May-13	18-Jun-13	75.0
37	CA1233203	21-May-13	18-Jun-13	64.0
38	CA1233204	21-May-13	18-Jun-13	66.0
39	CA1233209	21-May-13	18-Jun-13	68.0
40	CA1233210	21-May-13	18-Jun-13	66.0
41	CA1233994	21-May-13	18-Jun-13	69.5
42	CA1233995	21-May-13	18-Jun-13	70.0
43	CA1233970	21-May-13	18-Jun-13	69.5
44	CA1233971	21-May-13	18-Jun-13	70.0

45	CA1233985	21-May-13	18-Jun-13	68.5
46	CA1233986	21-May-13	18-Jun-13	68.5
47	CA1233991	21-May-13	18-Jun-13	70.5
48	CA1233992	21-May-13	18-Jun-13	70.5
49	CA1233248	21-May-13	18-Jun-13	74.0
50	CA1233249	21-May-13	18-Jun-13	73.0
51	CA1233251	21-May-13	18-Jun-13	75.0
52	CA1233252	21-May-13	18-Jun-13	75.5
53	CA1233218	21-May-13	18-Jun-13	77.0
54	CA1233219	21-May-13	18-Jun-13	77.0
55	CA1233242	21-May-13	18-Jun-13	79.0
56	CA1233243	21-May-13	18-Jun-13	77.5
57	CA1233949	21-May-13	18-Jun-13	73.0
58	CA1233950	21-May-13	18-Jun-13	70.5
59	CA1233961	21-May-13	18-Jun-13	70.5
60	CA1233962	21-May-13	18-Jun-13	71.0
61	CA1233982	21-May-13	18-Jun-13	68.0
62	CA1233983	21-May-13	18-Jun-13	66.5

Roof slab : T5

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1233502	10-Jun-13	8-Jul-13	71.0
2	CA1233514	10-Jun-13	8-Jul-13	69.5
3	CA1233532	10-Jun-13	8-Jul-13	68.5
4	CA1233541	10-Jun-13	8-Jul-13	71.0
5	CA1233501	10-Jun-13	8-Jul-13	70.5
6	CA1233513	10-Jun-13	8-Jul-13	70.0
7	CA1233531	10-Jun-13	8-Jul-13	64.5
8	CA1233540	10-Jun-13	8-Jul-13	68.5
9	CA1233402	10-Jun-13	8-Jul-13	65.5
10	CA1233405	10-Jun-13	8-Jul-13	67.0
11	CA1233408	10-Jun-13	8-Jul-13	64.5
12	CA1233411	10-Jun-13	8-Jul-13	64.5
13	CA1233417	10-Jun-13	8-Jul-13	64.0
14	CA1233420	10-Jun-13	8-Jul-13	68.0
15	CA1233426	10-Jun-13	8-Jul-13	68.5
16	CA1233435	10-Jun-13	8-Jul-13	67.0
17	CA1233441	10-Jun-13	8-Jul-13	70.0
18	CA1233450	10-Jun-13	8-Jul-13	71.5
19	CA1233453	10-Jun-13	8-Jul-13	75.0
20	CA1233456	10-Jun-13	8-Jul-13	70.0
21	CA1233465	10-Jun-13	8-Jul-13	73.5
22	CA1233471	10-Jun-13	8-Jul-13	78.5
23	CA1233477	10-Jun-13	8-Jul-13	83.0
24	CA1233480	10-Jun-13	8-Jul-13	64.0
25	CA1233483	10-Jun-13	8-Jul-13	65.0
26	CA1233492	10-Jun-13	8-Jul-13	69.0
27	CA1233495	10-Jun-13	8-Jul-13	67.5
28	CA1233403	10-Jun-13	8-Jul-13	65.0
29	CA1233406	10-Jun-13	8-Jul-13	65.5
30	CA1233409	10-Jun-13	8-Jul-13	61.5
31	CA1233412	10-Jun-13	8-Jul-13	66.5
32	CA1233418	10-Jun-13	8-Jul-13	66.5
33	CA1233421	10-Jun-13	8-Jul-13	66.5
34	CA1233427	10-Jun-13	8-Jul-13	70.0
35	CA1233436	10-Jun-13	8-Jul-13	66.5
36	CA1233442	10-Jun-13	8-Jul-13	67.5
37	CA1233451	10-Jun-13	8-Jul-13	71.5
38	CA1233454	10-Jun-13	8-Jul-13	77.0
39	CA1233457	10-Jun-13	8-Jul-13	74.5
40	CA1233466	10-Jun-13	8-Jul-13	74.0
41	CA1233472	10-Jun-13	8-Jul-13	80.0
42	CA1233478	10-Jun-13	8-Jul-13	86.0
43	CA1233481	10-Jun-13	8-Jul-13	66.5
44	CA1233484	10-Jun-13	8-Jul-13	63.0

45	CA1233493	10-Jun-13	8-Jul-13	73.5
46	CA1233496	10-Jun-13	8-Jul-13	67.5
47	CA1233414	10-Jun-13	8-Jul-13	65.5
48	CA1233423	10-Jun-13	8-Jul-13	70.5
49	CA1233429	10-Jun-13	8-Jul-13	71.0
50	CA1233468	10-Jun-13	8-Jul-13	72.0
51	CA1233486	10-Jun-13	8-Jul-13	61.5
52	CA1233489	10-Jun-13	8-Jul-13	69.0
53	CA1233432	10-Jun-13	8-Jul-13	70.5
54	CA1233438	10-Jun-13	8-Jul-13	68.0
55	CA1233444	10-Jun-13	8-Jul-13	63.5
56	CA1233447	10-Jun-13	8-Jul-13	71.0
57	CA1233459	10-Jun-13	8-Jul-13	71.5
58	CA1233462	10-Jun-13	8-Jul-13	76.5
59	CA1233474	10-Jun-13	8-Jul-13	78.0
60	CA1233498	10-Jun-13	8-Jul-13	69.0
61	CA1233507	10-Jun-13	8-Jul-13	70.5
62	CA1233510	10-Jun-13	8-Jul-13	70.5
63	CA1233415	10-Jun-13	8-Jul-13	66.5
64	CA1233424	10-Jun-13	8-Jul-13	67.5
65	CA1233430	10-Jun-13	8-Jul-13	69.5
66	CA1233469	10-Jun-13	8-Jul-13	76.5
67	CA1233487	10-Jun-13	8-Jul-13	61.5
68	CA1233490	10-Jun-13	8-Jul-13	73.5
69	CA1233433	10-Jun-13	8-Jul-13	62.5
70	CA1233439	10-Jun-13	8-Jul-13	68.5
71	CA1233445	10-Jun-13	8-Jul-13	71.0
72	CA1233448	10-Jun-13	8-Jul-13	68.5
73	CA1233460	10-Jun-13	8-Jul-13	72.0
74	CA1233463	10-Jun-13	8-Jul-13	78.5
75	CA1233475	10-Jun-13	8-Jul-13	76.5
76	CA1233499	10-Jun-13	8-Jul-13	68.0
77	CA1233508	10-Jun-13	8-Jul-13	68.5
78	CA1233511	10-Jun-13	8-Jul-13	75.5

Roof slab : T6

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1233570	24-Jun-13	22-Jul-13	63.5
2	CA1233573	24-Jun-13	22-Jul-13	64.0
3	CA1233597	24-Jun-13	22-Jul-13	64.0
4	CA1175009	24-Jun-13	22-Jul-13	61.5
5	CA1175012	24-Jun-13	22-Jul-13	61.5
6	CA1175021	24-Jun-13	22-Jul-13	63.0
7	CA1175027	24-Jun-13	22-Jul-13	62.0
8	CA1175033	24-Jun-13	22-Jul-13	61.0
9	CA1175039	24-Jun-13	22-Jul-13	58.5
10	CA1175048	24-Jun-13	22-Jul-13	62.5
11	CA1175057	24-Jun-13	22-Jul-13	65.0
12	CA1175066	24-Jun-13	22-Jul-13	65.0
13	CA1175069	24-Jun-13	22-Jul-13	70.5
14	CA1175081	24-Jun-13	22-Jul-13	68.0
15	CA1233571	24-Jun-13	22-Jul-13	62.5
16	CA1233574	24-Jun-13	22-Jul-13	63.5
17	CA1233598	24-Jun-13	22-Jul-13	63.5
18	CA1175010	24-Jun-13	22-Jul-13	63.5
19	CA1175013	24-Jun-13	22-Jul-13	62.5
20	CA1175022	24-Jun-13	22-Jul-13	65.5
21	CA1175028	24-Jun-13	22-Jul-13	66.0
22	CA1175034	24-Jun-13	22-Jul-13	63.5
23	CA1175040	24-Jun-13	22-Jul-13	56.5
24	CA1175049	24-Jun-13	22-Jul-13	64.0
25	CA1175058	24-Jun-13	22-Jul-13	60.5
26	CA1175067	24-Jun-13	22-Jul-13	65.5
27	CA1175070	24-Jun-13	22-Jul-13	69.0
28	CA1175082	24-Jun-13	22-Jul-13	73.5
29	CA1175087	24-Jun-13	22-Jul-13	66.5
30	CA1175090	24-Jun-13	22-Jul-13	64.5
31	CA1233549	24-Jun-13	22-Jul-13	68.0
32	CA1233552	24-Jun-13	22-Jul-13	66.5
33	CA1233555	24-Jun-13	22-Jul-13	64.0
34	CA1233564	24-Jun-13	22-Jul-13	65.5
35	CA1233567	24-Jun-13	22-Jul-13	68.0
36	CA1233576	24-Jun-13	22-Jul-13	62.0
37	CA1233579	24-Jun-13	22-Jul-13	70.5
38	CA1233582	24-Jun-13	22-Jul-13	69.5
39	CA1233588	24-Jun-13	22-Jul-13	66.0
40	CA1233591	24-Jun-13	22-Jul-13	65.5
41	CA1233594	24-Jun-13	22-Jul-13	65.0
42	CA1175003	24-Jun-13	22-Jul-13	63.0
43	CA1233558	24-Jun-13	22-Jul-13	65.5
44	CA1233561	24-Jun-13	22-Jul-13	60.5

45	CA1175084	24-Jun-13	22-Jul-13	62.0
46	CA1175072	24-Jun-13	22-Jul-13	64.0
47	CA1175075	24-Jun-13	22-Jul-13	63.0
48	CA1175078	24-Jun-13	22-Jul-13	66.0
49	CA1175054	24-Jun-13	22-Jul-13	67.5
50	CA1175060	24-Jun-13	22-Jul-13	64.0
51	CA1175063	24-Jun-13	22-Jul-13	64.0
52	CA1175042	24-Jun-13	22-Jul-13	59.5
53	CA1175045	24-Jun-13	22-Jul-13	59.5
54	CA1175051	24-Jun-13	22-Jul-13	66.0
55	CA1175024	24-Jun-13	22-Jul-13	60.0
56	CA1175030	24-Jun-13	22-Jul-13	62.0
57	CA1175036	24-Jun-13	22-Jul-13	64.5
58	CA1175006	24-Jun-13	22-Jul-13	62.5
59	CA1175015	24-Jun-13	22-Jul-13	64.0
60	CA1175018	24-Jun-13	22-Jul-13	61.5
61	CA1175088	24-Jun-13	22-Jul-13	65.0
62	CA1175091	24-Jun-13	22-Jul-13	68.5
63	CA1233550	24-Jun-13	22-Jul-13	66.5
64	CA1233553	24-Jun-13	22-Jul-13	63.5
65	CA1233556	24-Jun-13	22-Jul-13	61.0
66	CA1233565	24-Jun-13	22-Jul-13	66.5
67	CA1233568	24-Jun-13	22-Jul-13	65.5
68	CA1233577	24-Jun-13	22-Jul-13	65.0
69	CA1233580	24-Jun-13	22-Jul-13	66.0
70	CA1233583	24-Jun-13	22-Jul-13	67.9
71	CA1233589	24-Jun-13	22-Jul-13	66.0
72	CA1233592	24-Jun-13	22-Jul-13	65.0
73	CA1233595	24-Jun-13	22-Jul-13	66.0
74	CA1175004	24-Jun-13	22-Jul-13	65.0
75	CA1233559	24-Jun-13	22-Jul-13	65.5
76	CA1233562	24-Jun-13	22-Jul-13	66.0
77	CA1175085	24-Jun-13	22-Jul-13	66.0
78	CA1175073	24-Jun-13	22-Jul-13	66.5
79	CA1175076	24-Jun-13	22-Jul-13	70.0
80	CA1175079	24-Jun-13	22-Jul-13	67.0
81	CA1175055	24-Jun-13	22-Jul-13	65.5
82	CA1175061	24-Jun-13	22-Jul-13	62.5
83	CA1175064	24-Jun-13	22-Jul-13	62.0
84	CA1175043	24-Jun-13	22-Jul-13	59.5
85	CA1175046	24-Jun-13	22-Jul-13	61.0
86	CA1175052	24-Jun-13	22-Jul-13	66.0
87	CA1175025	24-Jun-13	22-Jul-13	65.5
88	CA1175031	24-Jun-13	22-Jul-13	65.0
89	CA1175037	24-Jun-13	22-Jul-13	64.5
90	CA1175007	24-Jun-13	22-Jul-13	63.5

91	CA1175016	24-Jun-13	22-Jul-13	65.0
92	CA1175019	24-Jun-13	22-Jul-13	63.5

Roof slab : T7 &T8

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1175746	28-Sep-13	26-Oct-13	70.5
2	CA1175747	28-Sep-13	26-Oct-13	72.0
3	CA1175752	28-Sep-13	26-Oct-13	68.5
4	CA1175753	28-Sep-13	26-Oct-13	69.5
5	CA1175755	28-Sep-13	26-Oct-13	67.5
6	CA1175756	28-Sep-13	26-Oct-13	67.0
7	CA1175782	28-Sep-13	26-Oct-13	70.0
8	CA1175783	28-Sep-13	26-Oct-13	70.0
9	CA1175797	28-Sep-13	26-Oct-13	68.5
10	CA1175798	28-Sep-13	26-Oct-13	69.0
11	CA1233609	28-Sep-13	26-Oct-13	64.0
12	CA1233610	28-Sep-13	26-Oct-13	63.5
13	CA1233630	28-Sep-13	26-Oct-13	71.0
14	CA1233631	28-Sep-13	26-Oct-13	67.5
15	CA1233642	28-Sep-13	26-Oct-13	59.5
16	CA1233643	28-Sep-13	26-Oct-13	62.5
17	CA1233654	28-Sep-13	26-Oct-13	67.5
18	CA1233655	28-Sep-13	26-Oct-13	69.5
19	CA1233663	28-Sep-13	26-Oct-13	62.5
20	CA1233664	28-Sep-13	26-Oct-13	63.5
21	CA1233675	28-Sep-13	26-Oct-13	64.5
22	CA1233676	28-Sep-13	26-Oct-13	62.5
23	CA1233687	28-Sep-13	26-Oct-13	64.5
24	CA1233688	28-Sep-13	26-Oct-13	64.0
25	CA1233699	28-Sep-13	26-Oct-13	61.5
26	CA1233700	28-Sep-13	26-Oct-13	63.0
27	CA1233708	28-Sep-13	26-Oct-13	62.5
28	CA1233709	28-Sep-13	26-Oct-13	58.0
29	CA1233720	28-Sep-13	26-Oct-13	64.5
30	CA1233721	28-Sep-13	26-Oct-13	66.0
31	CA1233702	28-Sep-13	26-Oct-13	61.0
32	CA1233703	28-Sep-13	26-Oct-13	62.5
33	CA1233714	28-Sep-13	26-Oct-13	61.5
34	CA1233715	28-Sep-13	26-Oct-13	64.5
35	CA1233732	28-Sep-13	26-Oct-13	66.0
36	CA1233733	28-Sep-13	26-Oct-13	66.5
37	CA1233678	28-Sep-13	26-Oct-13	62.5
38	CA1233679	28-Sep-13	26-Oct-13	65.5
39	CA1233684	28-Sep-13	26-Oct-13	67.0
40	CA1233685	28-Sep-13	26-Oct-13	64.5
41	CA1233693	28-Sep-13	26-Oct-13	66.5
42	CA1233694	28-Sep-13	26-Oct-13	61.5
43	CA1233657	28-Sep-13	26-Oct-13	67.0
44	CA1233658	28-Sep-13	26-Oct-13	68.0

45	CA1233666	28-Sep-13	26-Oct-13	63.5
46	CA1233667	28-Sep-13	26-Oct-13	64.5
47	CA1233669	28-Sep-13	26-Oct-13	65.5
48	CA1233670	28-Sep-13	26-Oct-13	64.5
49	CA1233603	28-Sep-13	26-Oct-13	65.5
50	CA1233604	28-Sep-13	26-Oct-13	66.5
51	CA1233615	28-Sep-13	26-Oct-13	60.0
52	CA1233616	28-Sep-13	26-Oct-13	62.0
53	CA1233618	28-Sep-13	26-Oct-13	61.0
54	CA1233619	28-Sep-13	26-Oct-13	69.0
55	CA1175767	28-Sep-13	26-Oct-13	66.5
56	CA1175768	28-Sep-13	26-Oct-13	67.5
57	CA1175785	28-Sep-13	26-Oct-13	65.5
58	CA1175786	28-Sep-13	26-Oct-13	64.5
59	CA1175800	28-Sep-13	26-Oct-13	66.0
60	CA1233601	28-Sep-13	26-Oct-13	67.0
61	CA1233734	28-Sep-13	26-Oct-13	62.0
62	CA1233735	28-Sep-13	26-Oct-13	67.0
63	CA1233737	28-Sep-13	26-Oct-13	64.0
64	CA1233738	28-Sep-13	26-Oct-13	66.0
65	CA1175758	28-Sep-13	26-Oct-13	64.5
66	CA1175759	28-Sep-13	26-Oct-13	69.5
67	CA1233627	28-Sep-13	26-Oct-13	63.5
68	CA1233628	28-Sep-13	26-Oct-13	69.0
69	CA1233633	28-Sep-13	26-Oct-13	70.5
70	CA1233634	28-Sep-13	26-Oct-13	69.5
71	CA1233648	28-Sep-13	26-Oct-13	66.0
72	CA1233649	28-Sep-13	26-Oct-13	67.0
73	CA1233735	28-Sep-13	26-Oct-13	61.5
74	CA1233736	28-Sep-13	26-Oct-13	63.0
75	CA1233738	28-Sep-13	26-Oct-13	49.5
76	CA1233739	28-Sep-13	26-Oct-13	54.5
77	CA1175716	28-Sep-13	26-Oct-13	63.0
78	CA1175717	28-Sep-13	26-Oct-13	65.0
79	CA1175718	28-Sep-13	26-Oct-13	63.0
80	CA1175719	28-Sep-13	26-Oct-13	66.5
81	CA1175720	28-Sep-13	26-Oct-13	66.5
82	CA1175721	28-Sep-13	26-Oct-13	65.5
83	CA1175725	28-Sep-13	26-Oct-13	65.0
84	CA1175726	28-Sep-13	26-Oct-13	65.5
85	CA1175728	28-Sep-13	26-Oct-13	66.5
86	CA1175729	28-Sep-13	26-Oct-13	66.5
87	CA1175731	28-Sep-13	26-Oct-13	66.5
88	CA1175732	28-Sep-13	26-Oct-13	66.5
89	CA1233723	28-Sep-13	26-Oct-13	65.5
90	CA1233724	28-Sep-13	26-Oct-13	66.5

91	CA1233726	28-Sep-13	26-Oct-13	65.0
92	CA1233727	28-Sep-13	26-Oct-13	65.0
93	CA1233729	28-Sep-13	26-Oct-13	67.0
94	CA1233730	28-Sep-13	26-Oct-13	64.5
95	CA1233645	28-Sep-13	26-Oct-13	58.0
96	CA1233646	28-Sep-13	26-Oct-13	67.0
97	CA1233651	28-Sep-13	26-Oct-13	70.0
98	CA1233652	28-Sep-13	26-Oct-13	70.0
99	CA1233660	28-Sep-13	26-Oct-13	64.5
100	CA1233661	28-Sep-13	26-Oct-13	70.0
101	CA1175776	28-Sep-13	26-Oct-13	67.5
102	CA1175777	28-Sep-13	26-Oct-13	69.5
103	CA1175779	28-Sep-13	26-Oct-13	71.0
104	CA1175780	28-Sep-13	26-Oct-13	72.0
105	CA1175791	28-Sep-13	26-Oct-13	61.0
106	CA1175792	28-Sep-13	26-Oct-13	63.0
107	CA1233705	28-Sep-13	26-Oct-13	61.0
108	CA1233706	28-Sep-13	26-Oct-13	60.5
109	CA1233711	28-Sep-13	26-Oct-13	60.5
110	CA1233712	28-Sep-13	26-Oct-13	63.0
111	CA1233717	28-Sep-13	26-Oct-13	66.0
112	CA1233718	28-Sep-13	26-Oct-13	66.0
113	CA1233672	28-Sep-13	26-Oct-13	65.0
114	CA1233673	28-Sep-13	26-Oct-13	67.5
115	CA1233681	28-Sep-13	26-Oct-13	64.0
116	CA1233682	28-Sep-13	26-Oct-13	66.0
117	CA1233696	28-Sep-13	26-Oct-13	62.0
118	CA1233697	28-Sep-13	26-Oct-13	62.5
119	CA1233621	28-Sep-13	26-Oct-13	64.0
120	CA1233622	28-Sep-13	26-Oct-13	67.5
121	CA1233624	28-Sep-13	26-Oct-13	67.0
122	CA1233625	28-Sep-13	26-Oct-13	65.5
123	CA1233636	28-Sep-13	26-Oct-13	75.0
124	CA1233637	28-Sep-13	26-Oct-13	59.0
125	CA1175794	28-Sep-13	26-Oct-13	70.5
126	CA1175795	28-Sep-13	26-Oct-13	66.5
127	CA1233606	28-Sep-13	26-Oct-13	65.5
128	CA1233607	28-Sep-13	26-Oct-13	64.0
129	CA1233612	28-Sep-13	26-Oct-13	64.0
130	CA1233613	28-Sep-13	26-Oct-13	63.5
131	CA1175761	28-Sep-13	26-Oct-13	68.5
132	CA1175762	28-Sep-13	26-Oct-13	70.0
133	CA1175764	28-Sep-13	26-Oct-13	68.5
134	CA1175765	28-Sep-13	26-Oct-13	67.5
135	CA1175770	28-Sep-13	26-Oct-13	68.0

136	CA1175771	28-Sep-13	26-Oct-13	69.5
137	CA1175740	28-Sep-13	26-Oct-13	71.5
138	CA1175741	28-Sep-13	26-Oct-13	66.5
139	CA1175743	28-Sep-13	26-Oct-13	72.0
140	CA1175744	28-Sep-13	26-Oct-13	72.5
141	CA1175749	28-Sep-13	26-Oct-13	59.0
142	CA1175750	28-Sep-13	26-Oct-13	63.5
143	CA1233690	28-Sep-13	26-Oct-13	59.5
144	CA1233691	28-Sep-13	26-Oct-13	66.5
145	CA1175773	28-Sep-13	26-Oct-13	72.5
146	CA1175774	28-Sep-13	26-Oct-13	68.0
147	CA1175788	28-Sep-13	26-Oct-13	60.5
148	CA1175789	28-Sep-13	26-Oct-13	63.0
149	CA1233639	28-Sep-13	26-Oct-13	62.0
150	CA1233640	28-Sep-13	26-Oct-13	63.0

Roof slab : T9

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1322556	15-Feb-14	15-Mar-14	75.0
2	CA1322557	15-Feb-14	15-Mar-14	71.5
3	CA1322559	15-Feb-14	15-Mar-14	71.0
4	CA1322560	15-Feb-14	15-Mar-14	71.0
5	CA1322562	15-Feb-14	15-Mar-14	68.5
6	CA1322563	15-Feb-14	15-Mar-14	51.0
7	CA1322565	15-Feb-14	15-Mar-14	62.5
8	CA1322566	15-Feb-14	15-Mar-14	61.0
9	CA1322568	15-Feb-14	15-Mar-14	69.0
10	CA1322569	15-Feb-14	15-Mar-14	65.0
11	CA1322547	15-Feb-14	15-Mar-14	69.0
12	CA1322548	15-Feb-14	15-Mar-14	68.0
13	CA1322550	15-Feb-14	15-Mar-14	64.0
14	CA1322551	15-Feb-14	15-Mar-14	69.0
15	CA1322553	15-Feb-14	15-Mar-14	68.0
16	CA1322554	15-Feb-14	15-Mar-14	68.5
17	CA1322538	15-Feb-14	15-Mar-14	69.0
18	CA1322539	15-Feb-14	15-Mar-14	64.5
19	CA1322541	15-Feb-14	15-Mar-14	63.5
20	CA1322542	15-Feb-14	15-Mar-14	66.0
21	CA1322544	15-Feb-14	15-Mar-14	66.0
22	CA1322545	15-Feb-14	15-Mar-14	65.5
23	CA1322526	15-Feb-14	15-Mar-14	70.0
24	CA1322527	15-Feb-14	15-Mar-14	70.0
25	CA1322532	15-Feb-14	15-Mar-14	70.0
26	CA1322533	15-Feb-14	15-Mar-14	68.5
27	CA1322535	15-Feb-14	15-Mar-14	68.0
28	CA1322536	15-Feb-14	15-Mar-14	66.0
29	CA1322487	15-Feb-14	15-Mar-14	66.5
30	CA1322488	15-Feb-14	15-Mar-14	60.0
31	CA1322493	15-Feb-14	15-Mar-14	62.0
32	CA1322494	15-Feb-14	15-Mar-14	65.5
33	CA1322511	15-Feb-14	15-Mar-14	57.0
34	CA1322512	15-Feb-14	15-Mar-14	58.5
35	CA1322463	15-Feb-14	15-Mar-14	67.0
36	CA1322464	15-Feb-14	15-Mar-14	63.5
37	CA1322475	15-Feb-14	15-Mar-14	68.0
38	CA1322476	15-Feb-14	15-Mar-14	64.5
39	CA1322478	15-Feb-14	15-Mar-14	60.5
40	CA1322479	15-Feb-14	15-Mar-14	67.0
41	CA1322403	15-Feb-14	15-Mar-14	67.0
42	CA1322404	15-Feb-14	15-Mar-14	66.5
43	CA1322406	15-Feb-14	15-Mar-14	63.5

44	CA1322407	15-Feb-14	15-Mar-14	67.0
45	CA1322460	15-Feb-14	15-Mar-14	62.5
46	CA1322461	15-Feb-14	15-Mar-14	63.0
47	CA1322514	15-Feb-14	15-Mar-14	58.5
48	CA1322515	15-Feb-14	15-Mar-14	59.0
49	CA1322529	15-Feb-14	15-Mar-14	69.0
50	CA1322530	15-Feb-14	15-Mar-14	60.0
51	CA1322484	15-Feb-14	15-Mar-14	64.5
52	CA1322485	15-Feb-14	15-Mar-14	63.0
53	CA1322490	15-Feb-14	15-Mar-14	65.0
54	CA1322491	15-Feb-14	15-Mar-14	64.0
55	CA1322505	15-Feb-14	15-Mar-14	65.0
56	CA1322506	15-Feb-14	15-Mar-14	68.5
57	CA1322448	15-Feb-14	15-Mar-14	63.0
58	CA1322449	15-Feb-14	15-Mar-14	74.5
59	CA1322466	15-Feb-14	15-Mar-14	64.5
60	CA1322467	15-Feb-14	15-Mar-14	68.0
61	CA1322481	15-Feb-14	15-Mar-14	61.5
62	CA1322482	15-Feb-14	15-Mar-14	66.0
63	CA1322427	15-Feb-14	15-Mar-14	75.0
64	CA1322428	15-Feb-14	15-Mar-14	69.0
65	CA1322430	15-Feb-14	15-Mar-14	73.0
66	CA1322431	15-Feb-14	15-Mar-14	73.0
67	CA1322436	15-Feb-14	15-Mar-14	69.0
68	CA1322437	15-Feb-14	15-Mar-14	72.0
69	CA1322418	15-Feb-14	15-Mar-14	68.5
70	CA1322419	15-Feb-14	15-Mar-14	69.0
71	CA1322421	15-Feb-14	15-Mar-14	73.5
72	CA1322422	15-Feb-14	15-Mar-14	66.5
73	CA1322424	15-Feb-14	15-Mar-14	68.5
74	CA1322425	15-Feb-14	15-Mar-14	68.5
75	CA1322409	15-Feb-14	15-Mar-14	67.0
76	CA1322410	15-Feb-14	15-Mar-14	67.5
77	CA1322412	15-Feb-14	15-Mar-14	66.5
78	CA1322413	15-Feb-14	15-Mar-14	69.0
79	CA1322415	15-Feb-14	15-Mar-14	64.0
80	CA1322416	15-Feb-14	15-Mar-14	69.5
81	CA1322499	15-Feb-14	15-Mar-14	65.0
82	CA1322470	15-Feb-14	15-Mar-14	64.0
83	CA1322502	15-Feb-14	15-Mar-14	65.5
84	CA1322503	15-Feb-14	15-Mar-14	64.5
85	CA1322520	15-Feb-14	15-Mar-14	58.0
86	CA1322521	15-Feb-14	15-Mar-14	57.0
87	CA1322433	15-Feb-14	15-Mar-14	62.5
88	CA1322434	15-Feb-14	15-Mar-14	65.0
89	CA1322442	15-Feb-14	15-Mar-14	65.0

90	CA1322443	15-Feb-14	15-Mar-14	61.5
91	CA1322454	15-Feb-14	15-Mar-14	63.0
92	CA1322455	15-Feb-14	15-Mar-14	63.0
93	CA1322397	15-Feb-14	15-Mar-14	70.5
94	CA1322398	15-Feb-14	15-Mar-14	71.0
95	CA1322400	15-Feb-14	15-Mar-14	71.5
96	CA1322401	15-Feb-14	15-Mar-14	71.5
97	CA1322523	15-Feb-14	15-Mar-14	68.0
98	CA1322524	15-Feb-14	15-Mar-14	60.5
99	CA1322499	15-Feb-14	15-Mar-14	61.0
100	CA1322500	15-Feb-14	15-Mar-14	65.0
101	CA1322508	15-Feb-14	15-Mar-14	66.5
102	CA1322509	15-Feb-14	15-Mar-14	66.5
103	CA1322517	15-Feb-14	15-Mar-14	70.5
104	CA1322518	15-Feb-14	15-Mar-14	69.5
105	CA1322457	15-Feb-14	15-Mar-14	73.5
106	CA1322458	15-Feb-14	15-Mar-14	74.0
107	CA1322472	15-Feb-14	15-Mar-14	72.5
108	CA1322473	15-Feb-14	15-Mar-14	70.5
109	CA1322496	15-Feb-14	15-Mar-14	64.5
110	CA1322497	15-Feb-14	15-Mar-14	66.0
111	CA1322439	15-Feb-14	15-Mar-14	65.0
112	CA1322440	15-Feb-14	15-Mar-14	68.5
113	CA1322445	15-Feb-14	15-Mar-14	67.5
114	CA1322446	15-Feb-14	15-Mar-14	69.5
115	CA1322451	15-Feb-14	15-Mar-14	58.0
116	CA1322452	15-Feb-14	15-Mar-14	69.5

Roof slab : T10

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1322577	22-Feb-14	22-Mar-14	64.0
2	CA1322578	22-Feb-14	22-Mar-14	62.5
3	CA1322580	22-Feb-14	22-Mar-14	61.5
4	CA1322581	22-Feb-14	22-Mar-14	66.5
5	CA1183127	22-Feb-14	22-Mar-14	51.5
6	CA1183128	22-Feb-14	22-Mar-14	49.5
7	CA1183082	22-Feb-14	22-Mar-14	57.0
8	CA1183083	22-Feb-14	22-Mar-14	58.0
9	CA1183085	22-Feb-14	22-Mar-14	59.5
10	CA1183086	22-Feb-14	22-Mar-14	60.5
11	CA1183094	22-Feb-14	22-Mar-14	59.0
12	CA1183095	22-Feb-14	22-Mar-14	64.0
13	CA1183097	22-Feb-14	22-Mar-14	60.0
14	CA1183098	22-Feb-14	22-Mar-14	62.5
15	CA1183100	22-Feb-14	22-Mar-14	62.0
16	CA1183101	22-Feb-14	22-Mar-14	61.5
17	CA1183103	22-Feb-14	22-Mar-14	60.5
18	CA1183104	22-Feb-14	22-Mar-14	64.0
19	CA1183106	22-Feb-14	22-Mar-14	64.0
20	CA1183107	22-Feb-14	22-Mar-14	63.0
21	CA1183109	22-Feb-14	22-Mar-14	66.0
22	CA1183110	22-Feb-14	22-Mar-14	68.5
23	CA1183133	22-Feb-14	22-Mar-14	67.5
24	CA1183134	22-Feb-14	22-Mar-14	69.0
25	CA1183055	22-Feb-14	22-Mar-14	62.0
26	CA1183056	22-Feb-14	22-Mar-14	61.5
27	CA1183058	22-Feb-14	22-Mar-14	60.0
28	CA1183059	22-Feb-14	22-Mar-14	61.0
29	CA1183064	22-Feb-14	22-Mar-14	61.5
30	CA1183065	22-Feb-14	22-Mar-14	64.0
31	CA1183067	22-Feb-14	22-Mar-14	58.0
32	CA1183068	22-Feb-14	22-Mar-14	53.5
33	CA1183076	22-Feb-14	22-Mar-14	58.5
34	CA1183077	22-Feb-14	22-Mar-14	64.0
35	CA1183079	22-Feb-14	22-Mar-14	62.5
36	CA1183080	22-Feb-14	22-Mar-14	64.0
37	CA1322586	22-Feb-14	22-Mar-14	65.0
38	CA1322587	22-Feb-14	22-Mar-14	67.5
39	CA1322589	22-Feb-14	22-Mar-14	70.5
40	CA1322590	22-Feb-14	22-Mar-14	71.0
41	CA1322592	22-Feb-14	22-Mar-14	67.0
42	CA1322593	22-Feb-14	22-Mar-14	68.0
43	CA1183013	22-Feb-14	22-Mar-14	67.0

44	CA1183014	22-Feb-14	22-Mar-14	66.0
45	CA1183016	22-Feb-14	22-Mar-14	69.0
46	CA1183017	22-Feb-14	22-Mar-14	68.5
47	CA1183019	22-Feb-14	22-Mar-14	65.0
48	CA1183020	22-Feb-14	22-Mar-14	51.5
49	CA1183025	22-Feb-14	22-Mar-14	64.0
50	CA1183026	22-Feb-14	22-Mar-14	65.5
51	CA1183028	22-Feb-14	22-Mar-14	68.5
52	CA1183029	22-Feb-14	22-Mar-14	67.5
53	CA1183034	22-Feb-14	22-Mar-14	55.0
54	CA1183035	22-Feb-14	22-Mar-14	55.0
55	CA1183037	22-Feb-14	22-Mar-14	53.5
56	CA1183038	22-Feb-14	22-Mar-14	52.5
57	CA1183049	22-Feb-14	22-Mar-14	65.0
58	CA1183047	22-Feb-14	22-Mar-14	62.5
59	CA1183052	22-Feb-14	22-Mar-14	63.0
60	CA1183053	22-Feb-14	22-Mar-14	61.0
61	CA1322598	22-Feb-14	22-Mar-14	68.5
62	CA1322599	22-Feb-14	22-Mar-14	71.0
63	CA1183001	22-Feb-14	22-Mar-14	66.0
64	CA1183002	22-Feb-14	22-Mar-14	70.0
65	CA1183007	22-Feb-14	22-Mar-14	66.5
66	CA1183008	22-Feb-14	22-Mar-14	65.5
67	CA1183040	22-Feb-14	22-Mar-14	61.0
68	CA1183041	22-Feb-14	22-Mar-14	61.5
69	CA1183043	22-Feb-14	22-Mar-14	63.5
70	CA1183044	22-Feb-14	22-Mar-14	63.5
71	CA1183112	22-Feb-14	22-Mar-14	57.5
72	CA1183113	22-Feb-14	22-Mar-14	62.0
73	CA1183124	22-Feb-14	22-Mar-14	64.5
74	CA1183125	22-Feb-14	22-Mar-14	64.5
75	CA1322595	22-Feb-14	22-Mar-14	68.5
76	CA1322596	22-Feb-14	22-Mar-14	67.5
77	CA1183004	22-Feb-14	22-Mar-14	66.0
78	CA1183005	22-Feb-14	22-Mar-14	66.5
79	CA1183010	22-Feb-14	22-Mar-14	70.5
80	CA1183011	22-Feb-14	22-Mar-14	69.0
81	CA1322583	22-Feb-14	22-Mar-14	69.5
82	CA1322584	22-Feb-14	22-Mar-14	68.0
83	CA1183022	22-Feb-14	22-Mar-14	65.5
84	CA1183023	22-Feb-14	22-Mar-14	64.5
85	CA1183031	22-Feb-14	22-Mar-14	61.0
86	CA1183032	22-Feb-14	22-Mar-14	62.0
87	CA1183049	22-Feb-14	22-Mar-14	63.5
88	CA1183050	22-Feb-14	22-Mar-14	65.5
89	CA1183061	22-Feb-14	22-Mar-14	62.5

90	CA1183062	22-Feb-14	22-Mar-14	63.0
91	CA1183070	22-Feb-14	22-Mar-14	56.5
92	CA1183071	22-Feb-14	22-Mar-14	57.0
93	CA1183073	22-Feb-14	22-Mar-14	58.0
94	CA1183074	22-Feb-14	22-Mar-14	58.5
95	CA1183088	22-Feb-14	22-Mar-14	58.5
96	CA1183089	22-Feb-14	22-Mar-14	62.5
97	CA1183091	22-Feb-14	22-Mar-14	60.5
98	CA1183092	22-Feb-14	22-Mar-14	60.0
99	CA1183115	22-Feb-14	22-Mar-14	62.5
100	CA1183116	22-Feb-14	22-Mar-14	62.0
101	CA1183118	22-Feb-14	22-Mar-14	56.5
102	CA1183119	22-Feb-14	22-Mar-14	60.5
103	CA1183121	22-Feb-14	22-Mar-14	47.5
104	CA1183122	22-Feb-14	22-Mar-14	52.0
105	CA1183130	22-Feb-14	22-Mar-14	53.0
106	CA1183131	22-Feb-14	22-Mar-14	51.5

Roof slab : T11

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1183136	27-Feb-14	27-Mar-14	57.5
2	CA1183137	27-Feb-14	27-Mar-14	56.0
3	CA1183142	27-Feb-14	27-Mar-14	60.5
4	CA1183143	27-Feb-14	27-Mar-14	59.5
5	CA1183145	27-Feb-14	27-Mar-14	57.5
6	CA1183146	27-Feb-14	27-Mar-14	62.5
7	CA1183157	27-Feb-14	27-Mar-14	63.5
8	CA1183158	27-Feb-14	27-Mar-14	65.5
9	CA1183148	27-Feb-14	27-Mar-14	65.0
10	CA1183149	27-Feb-14	27-Mar-14	64.5
11	CA1183151	27-Feb-14	27-Mar-14	65.5
12	CA1183152	27-Feb-14	27-Mar-14	63.0
13	CA1183154	27-Feb-14	27-Mar-14	60.0
14	CA1183155	27-Feb-14	27-Mar-14	63.0
15	CA1183232	27-Feb-14	27-Mar-14	66.5
16	CA1183233	27-Feb-14	27-Mar-14	67.5
17	CA1183235	27-Feb-14	27-Mar-14	61.5
18	CA1183236	27-Feb-14	27-Mar-14	61.5
19	CA1183238	27-Feb-14	27-Mar-14	65.0
20	CA1183239	27-Feb-14	27-Mar-14	63.0
21	CA1183223	27-Feb-14	27-Mar-14	60.5
22	CA1183224	27-Feb-14	27-Mar-14	61.5
23	CA1183226	27-Feb-14	27-Mar-14	62.5
24	CA1183227	27-Feb-14	27-Mar-14	63.0
25	CA1183229	27-Feb-14	27-Mar-14	65.0
26	CA1183230	27-Feb-14	27-Mar-14	64.0
27	CA1183214	27-Feb-14	27-Mar-14	58.0
28	CA1183215	27-Feb-14	27-Mar-14	58.5
29	CA1183217	27-Feb-14	27-Mar-14	61.5
30	CA1183218	27-Feb-14	27-Mar-14	60.5
31	CA1183220	27-Feb-14	27-Mar-14	60.0
32	CA1183221	27-Feb-14	27-Mar-14	60.5
33	CA1183205	27-Feb-14	27-Mar-14	61.5
34	CA1183206	27-Feb-14	27-Mar-14	62.5
35	CA1183208	27-Feb-14	27-Mar-14	65.0
36	CA1183209	27-Feb-14	27-Mar-14	62.5
37	CA1183211	27-Feb-14	27-Mar-14	58.5
38	CA1183212	27-Feb-14	27-Mar-14	59.0
39	CA1183178	27-Feb-14	27-Mar-14	61.0
40	CA1183179	27-Feb-14	27-Mar-14	62.0
41	CA1183181	27-Feb-14	27-Mar-14	62.0
42	CA1183182	27-Feb-14	27-Mar-14	62.5
43	CA1183184	27-Feb-14	27-Mar-14	62.5

44	CA1183185	27-Feb-14	27-Mar-14	63.0
45	CA1183196	27-Feb-14	27-Mar-14	58.0
46	CA1183197	27-Feb-14	27-Mar-14	57.5
47	CA1183199	27-Feb-14	27-Mar-14	62.5
48	CA1183200	27-Feb-14	27-Mar-14	62.0
49	CA1183202	27-Feb-14	27-Mar-14	60.5
50	CA1183203	27-Feb-14	27-Mar-14	60.0
51	CA1183187	27-Feb-14	27-Mar-14	59.5
52	CA1183188	27-Feb-14	27-Mar-14	60.5
53	CA1183190	27-Feb-14	27-Mar-14	58.0
54	CA1183191	27-Feb-14	27-Mar-14	57.5
55	CA1183193	27-Feb-14	27-Mar-14	59.0
56	CA1183194	27-Feb-14	27-Mar-14	58.0
57	CA1183169	27-Feb-14	27-Mar-14	61.0
58	CA1183170	27-Feb-14	27-Mar-14	62.0
59	CA1183172	27-Feb-14	27-Mar-14	62.0
60	CA1183173	27-Feb-14	27-Mar-14	64.5
61	CA1183175	27-Feb-14	27-Mar-14	63.5
62	CA1183176	27-Feb-14	27-Mar-14	64.0
63	CA1183160	27-Feb-14	27-Mar-14	62.5
64	CA1183161	27-Feb-14	27-Mar-14	63.0
65	CA1183163	27-Feb-14	27-Mar-14	64.5
66	CA1183164	27-Feb-14	27-Mar-14	65.0
67	CA1183166	27-Feb-14	27-Mar-14	62.0
68	CA183167	27-Feb-14	27-Mar-14	60.5
69	CA1183139	27-Feb-14	27-Mar-14	59.0
70	CA1183140	27-Feb-14	27-Mar-14	58.0

Roof slab : T12

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1183298	19-Mar-14	16-Apr-14	60.5
2	CA1183299	19-Mar-14	16-Apr-14	61.5
3	CA1183301	19-Mar-14	16-Apr-14	57.0
4	CA1183302	19-Mar-14	16-Apr-14	54.5
5	CA1183304	19-Mar-14	16-Apr-14	53.0
6	CA1183305	19-Mar-14	16-Apr-14	54.0
7	CA1183289	19-Mar-14	16-Apr-14	61.5
8	CA1183290	19-Mar-14	16-Apr-14	61.0
9	CA1183292	19-Mar-14	16-Apr-14	61.5
10	CA1183293	19-Mar-14	16-Apr-14	62.0
11	CA1183295	19-Mar-14	16-Apr-14	61.5
12	CA1183296	19-Mar-14	16-Apr-14	63.5
13	CA1183307	19-Mar-14	16-Apr-14	59.5
14	CA1183308	19-Mar-14	16-Apr-14	60.0
15	CA1183310	19-Mar-14	16-Apr-14	52.5
16	CA1183311	19-Mar-14	16-Apr-14	53.0
17	CA1183313	19-Mar-14	16-Apr-14	54.0
18	CA1183314	19-Mar-14	16-Apr-14	54.0
19	CA1183316	19-Mar-14	16-Apr-14	61.5
20	CA1183317	19-Mar-14	16-Apr-14	61.0
21	CA1183319	19-Mar-14	16-Apr-14	58.5
22	CA1183320	19-Mar-14	16-Apr-14	59.0
23	CA1183322	19-Mar-14	16-Apr-14	58.0
24	CA1183323	19-Mar-14	16-Apr-14	61.0
25	CA1183325	19-Mar-14	16-Apr-14	54.0
26	CA1183326	19-Mar-14	16-Apr-14	58.5
27	CA1183328	19-Mar-14	16-Apr-14	58.0
28	CA1183329	19-Mar-14	16-Apr-14	58.0

Tunnel Wall 01

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1417785	10-Apr-13	8-May-13	65.5
2	CA1417786	10-Apr-13	8-May-13	67.0
3	CA1417788	10-Apr-13	8-May-13	65.0
4	CA1417789	10-Apr-13	8-May-13	66.5
5	CA1417791	10-Apr-13	8-May-13	68.0
6	CA1417792	10-Apr-13	8-May-13	68.5
7	CA1233828	10-Apr-13	8-May-13	61.5
8	CA1233829	10-Apr-13	8-May-13	60.0
9	CA1233831	10-Apr-13	8-May-13	59.5
10	CA1233832	10-Apr-13	8-May-13	62.5
11	CA1233834	10-Apr-13	8-May-13	64.0
12	CA1233835	10-Apr-13	8-May-13	65.0
13	CA1233819	10-Apr-13	8-May-13	63.5
14	CA1233820	10-Apr-13	8-May-13	64.5
15	CA1233822	10-Apr-13	8-May-13	61.5
16	CA1233823	10-Apr-13	8-May-13	61.0
17	CA1233825	10-Apr-13	8-May-13	61.5
18	CA1233826	10-Apr-13	8-May-13	61.5
19	CA1233810	10-Apr-13	8-May-13	60.5
20	CA1233811	10-Apr-13	8-May-13	60.5
21	CA1233813	10-Apr-13	8-May-13	60.5
22	CA1233814	10-Apr-13	8-May-13	59.0
23	CA1233816	10-Apr-13	8-May-13	59.5
24	CA1233817	10-Apr-13	8-May-13	60.5
25	CA0881762	10-Apr-13	8-May-13	58.0
26	CA0881763	10-Apr-13	8-May-13	66.5
27	CA0881765	10-Apr-13	8-May-13	62.5
28	CA0881766	10-Apr-13	8-May-13	63.0
29	CA0881768	10-Apr-13	8-May-13	58.5
30	CA0881769	10-Apr-13	8-May-13	62.5
31	CA0881753	10-Apr-13	8-May-13	60.0
32	CA0881754	10-Apr-13	8-May-13	63.0
33	CA0881756	10-Apr-13	8-May-13	64.5
34	CA0881757	10-Apr-13	8-May-13	65.0
35	CA0881759	10-Apr-13	8-May-13	64.0
36	CA0881760	10-Apr-13	8-May-13	60.0
37	CA0881794	10-Apr-13	8-May-13	67.5
38	CA0881795	10-Apr-13	8-May-13	69.0
39	CA0881797	10-Apr-13	8-May-13	69.5
40	CA0881798	10-Apr-13	8-May-13	67.0
41	CA0881800	10-Apr-13	8-May-13	65.5
42	CA0881801	10-Apr-13	8-May-13	68.0
43	CA1233801	10-Apr-13	8-May-13	59.5

44	CA1233802	10-Apr-13	8-May-13	60.5
45	CA1233804	10-Apr-13	8-May-13	62.5
46	CA1233805	10-Apr-13	8-May-13	63.0
47	CA1233807	10-Apr-13	8-May-13	61.5
48	CA1233808	10-Apr-13	8-May-13	61.0

Tunnel Wall 02

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1417137	17-Apr-13	15-May-13	73.0
2	CA1417138	17-Apr-13	15-May-13	70.5
3	CA1417140	17-Apr-13	15-May-13	73.0
4	CA1417141	17-Apr-13	15-May-13	74.0
5	CA1417128	17-Apr-13	15-May-13	71.0
6	CA1417129	17-Apr-13	15-May-13	65.5
7	CA1417131	17-Apr-13	15-May-13	72.5
8	CA1417132	17-Apr-13	15-May-13	68.5
9	CA1417134	17-Apr-13	15-May-13	68.5
10	CA1417135	17-Apr-13	15-May-13	68.5
11	CA1417092	17-Apr-13	15-May-13	66.5
12	CA1417093	17-Apr-13	15-May-13	74.0
13	CA1417095	17-Apr-13	15-May-13	75.5
14	CA1417096	17-Apr-13	15-May-13	74.0
15	CA1417098	17-Apr-13	15-May-13	72.0
16	CA1417099	17-Apr-13	15-May-13	73.0
17	CA1417101	17-Apr-13	15-May-13	52.0
18	CA1417102	17-Apr-13	15-May-13	60.0
19	CA1417104	17-Apr-13	15-May-13	58.5
20	CA1417105	17-Apr-13	15-May-13	66.0
21	CA1417107	17-Apr-13	15-May-13	71.0
22	CA1417108	17-Apr-13	15-May-13	69.5
23	CA1417110	17-Apr-13	15-May-13	66.5
24	CA1417111	17-Apr-13	15-May-13	63.0
25	CA1417113	17-Apr-13	15-May-13	64.0
26	CA1417114	17-Apr-13	15-May-13	63.0
27	CA1417116	17-Apr-13	15-May-13	65.0
28	CA1417117	17-Apr-13	15-May-13	71.5
29	CA1417119	17-Apr-13	15-May-13	67.5
30	CA1417120	17-Apr-13	15-May-13	61.0
31	CA1417122	17-Apr-13	15-May-13	69.0
32	CA1417123	17-Apr-13	15-May-13	70.5
33	CA1417125	17-Apr-13	15-May-13	70.0
34	CA1417126	17-Apr-13	15-May-13	69.0

Tunnel Wall 03

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1175632	3-Sep-13	1-Oct-13	64.0
2	CA1175623	3-Sep-13	1-Oct-13	68.0
3	CA1175626	3-Sep-13	1-Oct-13	65.0
4	CA1175629	3-Sep-13	1-Oct-13	65.0
5	CA1175614	3-Sep-13	1-Oct-13	66.0
6	CA1175617	3-Sep-13	1-Oct-13	66.0
7	CA1175620	3-Sep-13	1-Oct-13	66.5
8	CA1175633	3-Sep-13	1-Oct-13	66.5
9	CA1175624	3-Sep-13	1-Oct-13	66.0
10	CA1175627	3-Sep-13	1-Oct-13	64.0
11	CA1175630	3-Sep-13	1-Oct-13	67.0
12	CA1175615	3-Sep-13	1-Oct-13	63.0
13	CA1175618	3-Sep-13	1-Oct-13	69.5
14	CA1175621	3-Sep-13	1-Oct-13	65.0

Tunnel Wall 04

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1322304	17-Jan-14	14-Feb-14	66.0
2	CA1322305	17-Jan-14	14-Feb-14	68.5
3	CA1322307	17-Jan-14	14-Feb-14	68.5
4	CA1322308	17-Jan-14	14-Feb-14	66.5
5	CA1322334	17-Jan-14	14-Feb-14	73.0
6	CA1322335	17-Jan-14	14-Feb-14	73.0
7	CA1322337	17-Jan-14	14-Feb-14	75.0
8	CA1322338	17-Jan-14	14-Feb-14	70.5
9	CA1322340	17-Jan-14	14-Feb-14	62.5
10	CA1322341	17-Jan-14	14-Feb-14	63.0
11	CA1322343	17-Jan-14	14-Feb-14	64.5
12	CA1322344	17-Jan-14	14-Feb-14	65.0
13	CA1322346	17-Jan-14	14-Feb-14	64.0
14	CA1322347	17-Jan-14	14-Feb-14	53.5
15	CA1322349	17-Jan-14	14-Feb-14	64.0
16	CA1322350	17-Jan-14	14-Feb-14	61.5
17	CA1322352	17-Jan-14	14-Feb-14	61.0
18	CA1322353	17-Jan-14	14-Feb-14	61.5
19	CA1322355	17-Jan-14	14-Feb-14	71.0
20	CA1322356	17-Jan-14	14-Feb-14	66.5
21	CA1322358	17-Jan-14	14-Feb-14	71.0
22	CA1322359	17-Jan-14	14-Feb-14	73.0
23	CA1322361	17-Jan-14	14-Feb-14	66.0
24	CA1322362	17-Jan-14	14-Feb-14	71.0
25	CA1322364	17-Jan-14	14-Feb-14	70.0
26	CA1322365	17-Jan-14	14-Feb-14	71.5
27	CA1322367	17-Jan-14	14-Feb-14	65.0
28	CA1322368	17-Jan-14	14-Feb-14	66.0
29	CA1322370	17-Jan-14	14-Feb-14	69.5
30	CA1322371	17-Jan-14	14-Feb-14	69.0
31	CA1322373	17-Jan-14	14-Feb-14	60.5
32	CA1322374	17-Jan-14	14-Feb-14	69.0
33	CA1322376	17-Jan-14	14-Feb-14	68.5
34	CA1322377	17-Jan-14	14-Feb-14	70.5
35	CA1322379	17-Jan-14	14-Feb-14	68.0
36	CA1322380	17-Jan-14	14-Feb-14	69.0
37	CA1322382	17-Jan-14	14-Feb-14	72.5
38	CA1322383	17-Jan-14	14-Feb-14	69.5

Tunnel Wall 05

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1417831	27-Mar-13	24-Apr-13	65.5
2	CA1417832	27-Mar-13	24-Apr-13	62.0
3	CA1417834	27-Mar-13	24-Apr-13	63.0
4	CA1417835	27-Mar-13	24-Apr-13	64.0
5	CA1417837	27-Mar-13	24-Apr-13	64.5
6	CA1417838	27-Mar-13	24-Apr-13	62.5
7	CA1417867	27-Mar-13	24-Apr-13	69.5
8	CA1417868	27-Mar-13	24-Apr-13	70.5
9	CA1417870	27-Mar-13	24-Apr-13	63.5
10	CA1417871	27-Mar-13	24-Apr-13	65.5
11	CA1417849	27-Mar-13	24-Apr-13	69.0
12	CA1417850	27-Mar-13	24-Apr-13	71.0
13	CA1417852	27-Mar-13	24-Apr-13	69.0
14	CA1417853	27-Mar-13	24-Apr-13	65.5
15	CA1417855	27-Mar-13	24-Apr-13	68.5
16	CA1417856	27-Mar-13	24-Apr-13	67.5
17	CA1417858	27-Mar-13	24-Apr-13	66.5
18	CA1417859	27-Mar-13	24-Apr-13	68.5
19	CA1417861	27-Mar-13	24-Apr-13	67.0
20	CA1417862	27-Mar-13	24-Apr-13	72.0
21	CA1417864	27-Mar-13	24-Apr-13	70.5
22	CA1417865	27-Mar-13	24-Apr-13	74.5
23	CA1417840	27-Mar-13	24-Apr-13	67.0
24	CA1417841	27-Mar-13	24-Apr-13	68.5
25	CA1417843	27-Mar-13	24-Apr-13	70.5
26	CA1417844	27-Mar-13	24-Apr-13	67.0
27	CA1417846	27-Mar-13	24-Apr-13	67.5
28	CA1417847	27-Mar-13	24-Apr-13	67.5
29	CA1417822	27-Mar-13	24-Apr-13	64.5
30	CA1417823	27-Mar-13	24-Apr-13	63.5
31	CA1417825	27-Mar-13	24-Apr-13	64.0
32	CA1417826	27-Mar-13	24-Apr-13	60.5
33	CA1417828	27-Mar-13	24-Apr-13	62.0
34	CA1417829	27-Mar-13	24-Apr-13	66.5
35	CA1417867	27-Mar-13	24-Apr-13	69.5
36	CA1417868	27-Mar-13	24-Apr-13	70.5
37	CA1417870	27-Mar-13	24-Apr-13	63.5
38	CA1417871	27-Mar-13	24-Apr-13	65.5

Tunnel Wall 06

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1417873	3-Apr-13	1-May-13	60.5
2	CA1417874	3-Apr-13	1-May-13	60.0
3	CA1417876	3-Apr-13	1-May-13	65.0
4	CA1417877	3-Apr-13	1-May-13	64.0
5	CA1417879	3-Apr-13	1-May-13	65.5
6	CA1417880	3-Apr-13	1-May-13	65.5
7	CA1417900	3-Apr-13	1-May-13	66.5
8	CA1417901	3-Apr-13	1-May-13	65.5
9	CA1417903	3-Apr-13	1-May-13	70.5
10	CA1417904	3-Apr-13	1-May-13	69.0
11	CA1417906	3-Apr-13	1-May-13	68.0
12	CA1417907	3-Apr-13	1-May-13	68.5
13	CA1417891	3-Apr-13	1-May-13	66.5
14	CA1417892	3-Apr-13	1-May-13	68.0
15	CA1417894	3-Apr-13	1-May-13	68.5
16	CA1417895	3-Apr-13	1-May-13	65.5
17	CA1417897	3-Apr-13	1-May-13	65.0
18	CA1417898	3-Apr-13	1-May-13	67.5
19	CA1417918	3-Apr-13	1-May-13	47.5
20	CA1417919	3-Apr-13	1-May-13	48.5
21	CA1417921	3-Apr-13	1-May-13	66.0
22	CA1417922	3-Apr-13	1-May-13	65.5
23	CA1417924	3-Apr-13	1-May-13	63.5
24	CA1417925	3-Apr-13	1-May-13	63.5
25	CA1417909	3-Apr-13	1-May-13	60.5
26	CA1417910	3-Apr-13	1-May-13	60.0
27	CA1417912	3-Apr-13	1-May-13	61.0
28	CA1417913	3-Apr-13	1-May-13	61.5
29	CA1417915	3-Apr-13	1-May-13	64.5
30	CA1417916	3-Apr-13	1-May-13	63.0
31	CA1417882	3-Apr-13	1-May-13	68.5
32	CA1417883	3-Apr-13	1-May-13	67.0
33	CA1417885	3-Apr-13	1-May-13	65.5
34	CA1417886	3-Apr-13	1-May-13	68.0
35	CA1417888	3-Apr-13	1-May-13	71.0
36	CA1417889	3-Apr-13	1-May-13	72.5

Tunnel Wall 07

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1417164	23-Apr-13	21-May-13	65.5
2	CA1417165	23-Apr-13	21-May-13	63.5
3	CA1417155	23-Apr-13	21-May-13	60.0
4	CA1417156	23-Apr-13	21-May-13	60.0
5	CA1417158	23-Apr-13	21-May-13	57.5
6	CA1417159	23-Apr-13	21-May-13	59.5
7	CA1417161	23-Apr-13	21-May-13	55.5
8	CA1417162	23-Apr-13	21-May-13	54.5

Tunnel Wall 08

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1322265	12-Jan-14	9-Feb-14	70.0
2	CA1322266	12-Jan-14	9-Feb-14	73.5
3	CA1322268	12-Jan-14	9-Feb-14	72.5
4	CA1322269	12-Jan-14	9-Feb-14	70.5
5	CA1322271	12-Jan-14	9-Feb-14	71.5
6	CA1322272	12-Jan-14	9-Feb-14	70.0
7	CA1322274	12-Jan-14	9-Feb-14	72.5
8	CA1322275	12-Jan-14	9-Feb-14	73.5
9	CA1322277	12-Jan-14	9-Feb-14	69.0
10	CA1322278	12-Jan-14	9-Feb-14	68.0
11	CA1322280	12-Jan-14	9-Feb-14	69.0
12	CA1322281	12-Jan-14	9-Feb-14	70.5
13	CA1322283	12-Jan-14	9-Feb-14	70.5
14	CA1322284	12-Jan-14	9-Feb-14	68.5
15	CA1322286	12-Jan-14	9-Feb-14	71.0
16	CA1322287	12-Jan-14	9-Feb-14	69.5
17	CA1322289	12-Jan-14	9-Feb-14	73.5
18	CA1322290	12-Jan-14	9-Feb-14	72.5
19	CA1322292	12-Jan-14	9-Feb-14	71.5
20	CA1322293	12-Jan-14	9-Feb-14	72.0
21	CA1322295	12-Jan-14	9-Feb-14	70.0
22	CA1322296	12-Jan-14	9-Feb-14	68.0
23	CA1322298	12-Jan-14	9-Feb-14	69.0
24	CA1322299	12-Jan-14	9-Feb-14	72.0
25	CA1322301	12-Jan-14	9-Feb-14	66.5
26	CA1322302	12-Jan-14	9-Feb-14	72.0
27	CA1322328	12-Jan-14	9-Feb-14	70.0
28	CA1322329	12-Jan-14	9-Feb-14	71.5
29	CA1322331	12-Jan-14	9-Feb-14	68.5
30	CA1322332	12-Jan-14	9-Feb-14	67.5
31	CA1322310	12-Jan-14	9-Feb-14	66.0
32	CA1322311	12-Jan-14	9-Feb-14	69.5
33	CA1322313	12-Jan-14	9-Feb-14	71.5
34	CA1322314	12-Jan-14	9-Feb-14	70.5
35	CA1322316	12-Jan-14	9-Feb-14	70.0
36	CA1322317	12-Jan-14	9-Feb-14	66.5
37	CA1322319	12-Jan-14	9-Feb-14	70.5
38	CA1322320	12-Jan-14	9-Feb-14	67.5
39	CA1322322	12-Jan-14	9-Feb-14	73.0
40	CA1322323	12-Jan-14	9-Feb-14	75.0
41	CA1322325	12-Jan-14	9-Feb-14	68.0
42	CA1322326	12-Jan-14	9-Feb-14	71.0
43	CA1183364	12-Jan-14	9-Feb-14	47.0

44	CA1183365	12-Jan-14	9-Feb-14	48.0
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Tunnel Wall 09

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1417334	11-Mar-13	8-Apr-13	61.0
2	CA1417335	11-Mar-13	8-Apr-13	64.0
3	CA1417337	11-Mar-13	8-Apr-13	62.0
4	CA1417338	11-Mar-13	8-Apr-13	63.0
5	CA1417340	11-Mar-13	8-Apr-13	62.0
6	CA1417341	11-Mar-13	8-Apr-13	62.0
7	CA1417352	11-Mar-13	8-Apr-13	64.0
8	CA1417353	11-Mar-13	8-Apr-13	64.5
9	CA1417355	11-Mar-13	8-Apr-13	66.0
10	CA1417356	11-Mar-13	8-Apr-13	66.0
11	CA1417358	11-Mar-13	8-Apr-13	62.5
12	CA1417359	11-Mar-13	8-Apr-13	63.0
13	CA1417361	11-Mar-13	8-Apr-13	64.5
14	CA1417362	11-Mar-13	8-Apr-13	65.0
15	CA1417364	11-Mar-13	8-Apr-13	62.5
16	CA1417365	11-Mar-13	8-Apr-13	62.5
17	CA1417367	11-Mar-13	8-Apr-13	64.0
18	CA1417368	11-Mar-13	8-Apr-13	62.0
19	CA1417370	11-Mar-13	8-Apr-13	64.0
20	CA1417371	11-Mar-13	8-Apr-13	66.0
21	CA1417373	11-Mar-13	8-Apr-13	65.5
22	CA1417374	11-Mar-13	8-Apr-13	65.5
23	CA1417376	11-Mar-13	8-Apr-13	64.0
24	CA1417377	11-Mar-13	8-Apr-13	66.0
25	CA1417325	11-Mar-13	8-Apr-13	64.5
26	CA1417326	11-Mar-13	8-Apr-13	64.5
27	CA1417328	11-Mar-13	8-Apr-13	64.5
28	CA1417329	11-Mar-13	8-Apr-13	64.5
29	CA1417331	11-Mar-13	8-Apr-13	66.5
30	CA1417332	11-Mar-13	8-Apr-13	65.5
31	CA1417343	11-Mar-13	8-Apr-13	65.5
32	CA1417344	11-Mar-13	8-Apr-13	63.5
33	CA1417346	11-Mar-13	8-Apr-13	61.5
34	CA1417347	11-Mar-13	8-Apr-13	62.5
35	CA1417349	11-Mar-13	8-Apr-13	61.5
36	CA1417350	11-Mar-13	8-Apr-13	62.0
37	CA1417379	11-Mar-13	8-Apr-13	64.5
38	CA1417380	11-Mar-13	8-Apr-13	65.5
39	CA1417382	11-Mar-13	8-Apr-13	69.0
40	CA1417383	11-Mar-13	8-Apr-13	67.5

Tunnel Wall 10

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1417387	16-Mar-13	13-Apr-13	63.5
2	CA1417388	16-Mar-13	13-Apr-13	60.5
3	CA1417390	16-Mar-13	13-Apr-13	66.5
4	CA1417391	16-Mar-13	13-Apr-13	65.5
5	CA1417393	16-Mar-13	13-Apr-13	65.5
6	CA1417394	16-Mar-13	13-Apr-13	63.5
7	CA1417443	16-Mar-13	13-Apr-13	59.0
8	CA1417444	16-Mar-13	13-Apr-13	58.0
9	CA1417416	16-Mar-13	13-Apr-13	62.0
10	CA1417417	16-Mar-13	13-Apr-13	61.5
11	CA1417419	16-Mar-13	13-Apr-13	62.5
12	CA1417420	16-Mar-13	13-Apr-13	64.0
13	CA1417422	16-Mar-13	13-Apr-13	59.0
14	CA1417423	16-Mar-13	13-Apr-13	59.5
15	CA1417425	16-Mar-13	13-Apr-13	61.0
16	CA1417426	16-Mar-13	13-Apr-13	59.0
17	CA1417428	16-Mar-13	13-Apr-13	57.0
18	CA1417429	16-Mar-13	13-Apr-13	54.0
19	CA1417431	16-Mar-13	13-Apr-13	56.0
20	CA1417432	16-Mar-13	13-Apr-13	56.5
21	CA1417407	16-Mar-13	13-Apr-13	61.5
22	CA1417408	16-Mar-13	13-Apr-13	64.0
23	CA1417410	16-Mar-13	13-Apr-13	62.5
24	CA1417411	16-Mar-13	13-Apr-13	61.5
25	CA1417413	16-Mar-13	13-Apr-13	65.5
26	CA1417414	16-Mar-13	13-Apr-13	63.5
27	CA1417434	16-Mar-13	13-Apr-13	62.0
28	CA1417435	16-Mar-13	13-Apr-13	63.5
29	CA1417437	16-Mar-13	13-Apr-13	61.5
30	CA1417438	16-Mar-13	13-Apr-13	64.0
31	CA1417440	16-Mar-13	13-Apr-13	58.0
32	CA1417441	16-Mar-13	13-Apr-13	60.5

Tunnel Wall 11

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1233862	26-Apr-13	24-May-13	61.5
2	CA1233863	26-Apr-13	24-May-13	62.5
3	CA1233853	26-Apr-13	24-May-13	69.0
4	CA1233854	26-Apr-13	24-May-13	70.0
5	CA1233856	26-Apr-13	24-May-13	58.5
6	CA1233857	26-Apr-13	24-May-13	63.5
7	CA1233859	26-Apr-13	24-May-13	64.0
8	CA1233860	26-Apr-13	24-May-13	64.0
9	CA1417197	26-Apr-13	24-May-13	68.5
10	CA1417198	26-Apr-13	24-May-13	72.0
11	CA1233847	26-Apr-13	24-May-13	71.5
12	CA1233848	26-Apr-13	24-May-13	65.5
13	CA1233850	26-Apr-13	24-May-13	64.5
14	CA1233851	26-Apr-13	24-May-13	67.0
15	CA1417199	26-Apr-13	24-May-13	67.0
16	CA1417200	26-Apr-13	24-May-13	67.5
17	CA1417191	26-Apr-13	24-May-13	67.5
18	CA1417192	26-Apr-13	24-May-13	69.5
19	CA1417194	26-Apr-13	24-May-13	66.5
20	CA1417195	26-Apr-13	24-May-13	68.5
21	CA1417176	26-Apr-13	24-May-13	76.0
22	CA1417177	26-Apr-13	24-May-13	79.5
23	CA1417185	26-Apr-13	24-May-13	76.5
24	CA1417186	26-Apr-13	24-May-13	77.0
25	CA1417188	26-Apr-13	24-May-13	76.5
26	CA1417189	26-Apr-13	24-May-13	76.0

Tunnel Wall 12

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1175578	24-Aug-13	23-Aug-13	58.0
2	CA1175579	24-Aug-13	23-Aug-13	59.0

Tunnel Wall 13

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1322193	11-Jan-14	8-Feb-14	79.5
2	CA1322194	11-Jan-14	8-Feb-14	79.5
3	CA1322196	11-Jan-14	8-Feb-14	79.0
4	CA1322197	11-Jan-14	8-Feb-14	78.5
5	CA1322199	11-Jan-14	8-Feb-14	79.5
6	CA1322200	11-Jan-14	8-Feb-14	81.5
7	CA1322241	11-Jan-14	8-Feb-14	65.0
8	CA1322242	11-Jan-14	8-Feb-14	63.0
9	CA1322244	11-Jan-14	8-Feb-14	68.5
10	CA1322245	11-Jan-14	8-Feb-14	70.0
11	CA1322211	11-Jan-14	8-Feb-14	76.0
12	CA1322212	11-Jan-14	8-Feb-14	74.0
13	CA1322214	11-Jan-14	8-Feb-14	75.0
14	CA1322215	11-Jan-14	8-Feb-14	70.5
15	CA1322220	11-Jan-14	8-Feb-14	74.5
16	CA1322221	11-Jan-14	8-Feb-14	74.0
17	CA1322202	11-Jan-14	8-Feb-14	75.0
18	CA1322203	11-Jan-14	8-Feb-14	74.0
19	CA1322205	11-Jan-14	8-Feb-14	73.0
20	CA1322206	11-Jan-14	8-Feb-14	73.5
21	CA1322208	11-Jan-14	8-Feb-14	75.5
22	CA1322209	11-Jan-14	8-Feb-14	74.5
23	CA1322256	11-Jan-14	8-Feb-14	76.0
24	CA1322257	11-Jan-14	8-Feb-14	77.0
25	CA1322259	11-Jan-14	8-Feb-14	70.0
26	CA1322260	11-Jan-14	8-Feb-14	77.5
27	CA1322262	11-Jan-14	8-Feb-14	77.0
28	CA1322263	11-Jan-14	8-Feb-14	70.0
29	CA1322247	11-Jan-14	8-Feb-14	72.0
30	CA1322248	11-Jan-14	8-Feb-14	71.0
31	CA1322250	11-Jan-14	8-Feb-14	68.0
32	CA1322251	11-Jan-14	8-Feb-14	72.0
33	CA1322254	11-Jan-14	8-Feb-14	69.5
34	CA1322253	11-Jan-14	8-Feb-14	66.5
35	CA1322232	11-Jan-14	8-Feb-14	61.5
36	CA1322233	11-Jan-14	8-Feb-14	61.0
37	CA1322235	11-Jan-14	8-Feb-14	64.5
38	CA1322236	11-Jan-14	8-Feb-14	62.5
39	CA1322238	11-Jan-14	8-Feb-14	61.0
40	CA1322239	11-Jan-14	8-Feb-14	64.0

Tunnel Wall 15B

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1233892	4-May-13	1-Jun-13	72.0
2	CA1233893	4-May-13	1-Jun-13	75.0
3	CA1233895	4-May-13	1-Jun-13	73.0
4	CA1233896	4-May-13	1-Jun-13	70.0
5	CA1233898	4-May-13	1-Jun-13	72.0
6	CA1233899	4-May-13	1-Jun-13	72.0
7	CA1233901	4-May-13	1-Jun-13	74.0
8	CA1233902	4-May-13	1-Jun-13	73.5
9	CA1233904	4-May-13	1-Jun-13	71.0
10	CA1233905	4-May-13	1-Jun-13	73.0
11	CA1233907	4-May-13	1-Jun-13	72.0
12	CA1233908	4-May-13	1-Jun-13	71.5
13	CA1233919	4-May-13	1-Jun-13	72.5
14	CA1233920	4-May-13	1-Jun-13	74.0
15	CA1233865	4-May-13	1-Jun-13	75.5
16	CA1233866	4-May-13	1-Jun-13	77.0
17	CA1233868	4-May-13	1-Jun-13	74.0
18	CA1233869	4-May-13	1-Jun-13	74.5
19	CA1233871	4-May-13	1-Jun-13	74.5
20	CA1233872	4-May-13	1-Jun-13	72.5
21	CA1233874	4-May-13	1-Jun-13	74.0
22	CA1233875	4-May-13	1-Jun-13	74.5
23	CA1233877	4-May-13	1-Jun-13	67.0
24	CA1233878	4-May-13	1-Jun-13	65.0
25	CA1233880	4-May-13	1-Jun-13	66.0
26	CA1233881	4-May-13	1-Jun-13	63.5
27	CA1233883	4-May-13	1-Jun-13	64.0
28	CA1233884	4-May-13	1-Jun-13	63.5
29	CA1233886	4-May-13	1-Jun-13	72.0
30	CA1233887	4-May-13	1-Jun-13	71.5
31	CA1233889	4-May-13	1-Jun-13	71.5
32	CA1233890	4-May-13	1-Jun-13	71.0

Base slab - B1-1 & B2-1

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1417448	18-Mar-13	15-Apr-13	63.0
2	CA1417447	18-Mar-13	15-Apr-13	61.5
3	CA1417446	18-Mar-13	15-Apr-13	62.0
4	CA1417445	18-Mar-13	15-Apr-13	62.0
5	CA1417811	18-Mar-13	15-Apr-13	63.0
6	CA1417812	18-Mar-13	15-Apr-13	62.0
7	CA1417814	18-Mar-13	15-Apr-13	61.5
8	CA1417815	18-Mar-13	15-Apr-13	61.5
9	CA1417817	18-Mar-13	15-Apr-13	67.0
10	CA1417817	18-Mar-13	15-Apr-13	65.5
11	CA1417542	18-Mar-13	15-Apr-13	68.5
12	CA1417541	18-Mar-13	15-Apr-13	66.0
13	CA1417527	18-Mar-13	15-Apr-13	66.0
14	CA1417526	18-Mar-13	15-Apr-13	70.0
15	CA1417808	18-Mar-13	15-Apr-13	61.0
16	CA1417809	18-Mar-13	15-Apr-13	65.5
17	CA1417455	18-Mar-13	15-Apr-13	67.0
18	CA1417454	18-Mar-13	15-Apr-13	70.0
19	CA1417452	18-Mar-13	15-Apr-13	66.5
20	CA1417451	18-Mar-13	15-Apr-13	68.0
21	CA1417802	18-Mar-13	15-Apr-13	62.0
22	CA1417803	18-Mar-13	15-Apr-13	59.0
23	CA1417464	18-Mar-13	15-Apr-13	69.0
24	CA1417463	18-Mar-13	15-Apr-13	70.5
25	CA1417461	18-Mar-13	15-Apr-13	68.5
26	CA1417460	18-Mar-13	15-Apr-13	67.5
27	CA1417458	18-Mar-13	15-Apr-13	71.0
28	CA1417457	18-Mar-13	15-Apr-13	70.5
29	CA1417473	18-Mar-13	15-Apr-13	65.0
30	CA1417472	18-Mar-13	15-Apr-13	66.0
31	CA1417470	18-Mar-13	15-Apr-13	66.5
32	CA1417469	18-Mar-13	15-Apr-13	66.5
33	CA1417467	18-Mar-13	15-Apr-13	64.0
34	CA1417466	18-Mar-13	15-Apr-13	67.5
35	CA1417557	18-Mar-13	15-Apr-13	68.0
36	CA1417556	18-Mar-13	15-Apr-13	66.5
37	CA1417479	18-Mar-13	15-Apr-13	63.5
38	CA1417478	18-Mar-13	15-Apr-13	64.0
39	CA1417476	18-Mar-13	15-Apr-13	65.0
40	CA1417475	18-Mar-13	15-Apr-13	62.0
41	CA1417566	18-Mar-13	15-Apr-13	67.5

42	CA1417565	18-Mar-13	15-Apr-13	70.5
43	CA1417563	18-Mar-13	15-Apr-13	70.5
44	CA1417562	18-Mar-13	15-Apr-13	72.5
45	CA1417560	18-Mar-13	15-Apr-13	65.0
46	CA1417559	18-Mar-13	15-Apr-13	67.0

Base slab - B1-2 & B2-2

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1417467	18-Mar-13	15-Apr-13	
2	CA1417466	18-Mar-13	15-Apr-13	64.0
3	CA1417470	18-Mar-13	15-Apr-13	67.5
4	CA1417469	18-Mar-13	15-Apr-13	66.5
5	CA1417473	18-Mar-13	15-Apr-13	66.5
6	CA1417472	18-Mar-13	15-Apr-13	65.0
7	CA1417569	18-Mar-13	15-Apr-13	66.0
8	CA1417568	18-Mar-13	15-Apr-13	73.5
9	CA1417581	18-Mar-13	15-Apr-13	70.5
10	CA1417580	18-Mar-13	15-Apr-13	65.0
11	CA1417587	18-Mar-13	15-Apr-13	62.5
12	CA1417586	18-Mar-13	15-Apr-13	66.5
13	CA1417590	18-Mar-13	15-Apr-13	67.5
14	CA1417589	18-Mar-13	15-Apr-13	67.0
15	CA1417593	18-Mar-13	15-Apr-13	68.0
16	CA1417592	18-Mar-13	15-Apr-13	69.5
17	CA1417596	18-Mar-13	15-Apr-13	66.5
18	CA1417595	18-Mar-13	15-Apr-13	67.0
19	CA1417560	18-Mar-13	15-Apr-13	65.0
20	CA1417559	18-Mar-13	15-Apr-13	65.0
21	CA1417563	18-Mar-13	15-Apr-13	67.0
22	CA1417562	18-Mar-13	15-Apr-13	70.5
23	CA1417566	18-Mar-13	15-Apr-13	72.5
24	CA1417565	18-Mar-13	15-Apr-13	67.5
25	CA1417476	18-Mar-13	15-Apr-13	70.5
26	CA1417475	18-Mar-13	15-Apr-13	65.0
27	CA1417479	18-Mar-13	15-Apr-13	62.0
28	CA1417478	18-Mar-13	15-Apr-13	63.5
29	CA1417557	18-Mar-13	15-Apr-13	64.0
30	CA1417556	18-Mar-13	15-Apr-13	68.0
31	CA1417458	18-Mar-13	15-Apr-13	66.5
32	CA1417457	18-Mar-13	15-Apr-13	71.0
33	CA1417461	18-Mar-13	15-Apr-13	70.5
34	CA1417460	18-Mar-13	15-Apr-13	68.5
35	CA1417464	18-Mar-13	15-Apr-13	67.5
36	CA1417463	18-Mar-13	15-Apr-13	69.0
37	CA1417524	18-Mar-13	15-Apr-13	65.5
38	CA1417523	18-Mar-13	15-Apr-13	66.5
39	CA1417536	18-Mar-13	15-Apr-13	66.0
40	CA1417535	18-Mar-13	15-Apr-13	73.5
41	CA1417805	18-Mar-13	15-Apr-13	61.0

42	CA1417806	18-Mar-13	15-Apr-13	62.5
43	CA1417452	18-Mar-13	15-Apr-13	66.5
44	CA1417451	18-Mar-13	15-Apr-13	68.0
45	CA1417455	18-Mar-13	15-Apr-13	67.0
46	CA1417454	18-Mar-13	15-Apr-13	70.0
47	CA1417802	18-Mar-13	15-Apr-13	62.0

Base slab - B3-2 & B4-2

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1417725	25-Mar-13	22-Apr-13	58.5
2	CA1417726	25-Mar-13	22-Apr-13	59.0
3	CA1417728	25-Mar-13	22-Apr-13	58.0
4	CA1417729	25-Mar-13	22-Apr-13	60.5
5	CA1417731	25-Mar-13	22-Apr-13	63.0
6	CA1417732	25-Mar-13	22-Apr-13	60.0
7	CA1417665	25-Mar-13	22-Apr-13	74.5
8	CA1417666	25-Mar-13	22-Apr-13	74.5
9	CA1417671	25-Mar-13	22-Apr-13	74.5
10	CA1417672	25-Mar-13	22-Apr-13	72.0
11	CA1417680	25-Mar-13	22-Apr-13	73.0
12	CA1417681	25-Mar-13	22-Apr-13	75.0
13	CA1417686	25-Mar-13	22-Apr-13	70.5
14	CA1417687	25-Mar-13	22-Apr-13	71.0
15	CA1417695	25-Mar-13	22-Apr-13	75.0
16	CA1417696	25-Mar-13	22-Apr-13	73.0
17	CA1417698	25-Mar-13	22-Apr-13	69.0
18	CA1417699	25-Mar-13	22-Apr-13	71.0
19	CA1417704	25-Mar-13	22-Apr-13	73.0
20	CA1417705	25-Mar-13	22-Apr-13	73.5
21	CA1417707	25-Mar-13	22-Apr-13	72.5
22	CA1417708	25-Mar-13	22-Apr-13	75.5
23	CA1417710	25-Mar-13	22-Apr-13	69.5
24	CA1417711	25-Mar-13	22-Apr-13	75.5
25	CA1417713	25-Mar-13	22-Apr-13	69.0
26	CA1417714	25-Mar-13	22-Apr-13	69.0
27	CA1417719	25-Mar-13	22-Apr-13	73.0
28	CA1417720	25-Mar-13	22-Apr-13	73.0
29	CA1417722	25-Mar-13	22-Apr-13	58.5
30	CA1417723	25-Mar-13	22-Apr-13	73.5
31	CA1417734	25-Mar-13	22-Apr-13	64.5
32	CA1417735	25-Mar-13	22-Apr-13	65.0
33	CA1417737	25-Mar-13	22-Apr-13	64.5
34	CA1417738	25-Mar-13	22-Apr-13	66.0
35	CA1417740	25-Mar-13	22-Apr-13	59.5
36	CA1417741	25-Mar-13	22-Apr-13	65.0
37	CA1417743	25-Mar-13	22-Apr-13	69.0
38	CA1417744	25-Mar-13	22-Apr-13	62.5
39	CA1417752	25-Mar-13	22-Apr-13	73.0
40	CA1417753	25-Mar-13	22-Apr-13	70.5
41	CA1417755	25-Mar-13	22-Apr-13	73.0
42	CA1417756	25-Mar-13	22-Apr-13	71.5

43	CA1417761	25-Mar-13	22-Apr-13	74.0
44	CA1417762	25-Mar-13	22-Apr-13	71.0
45	CA1417767	25-Mar-13	22-Apr-13	74.0
46	CA1417768	25-Mar-13	22-Apr-13	73.5
47	CA1417770	25-Mar-13	22-Apr-13	66.5
48	CA1417771	25-Mar-13	22-Apr-13	67.5
49	CA1417674	25-Mar-13	22-Apr-13	72.5
50	CA1417675	25-Mar-13	22-Apr-13	74.5
51	CA1417677	25-Mar-13	22-Apr-13	69.0
52	CA1417678	25-Mar-13	22-Apr-13	73.5
53	CA1417746	25-Mar-13	22-Apr-13	68.0
54	CA1417747	25-Mar-13	22-Apr-13	63.5
55	CA1417602	25-Mar-13	22-Apr-13	57.0
56	CA1417603	25-Mar-13	22-Apr-13	57.0
57	CA1417605	25-Mar-13	22-Apr-13	57.5
58	CA1417606	25-Mar-13	22-Apr-13	58.5
59	CA1417608	25-Mar-13	22-Apr-13	59.0
60	CA1417609	25-Mar-13	22-Apr-13	55.5
61	CA1417668	25-Mar-13	22-Apr-13	73.0
62	CA1417669	25-Mar-13	22-Apr-13	76.0
63	CA1417764	25-Mar-13	22-Apr-13	70.5
64	CA1417765	25-Mar-13	22-Apr-13	71.0
65	CA1417779	25-Mar-13	22-Apr-13	69.5
66	CA1417780	25-Mar-13	22-Apr-13	69.5
67	CA1417782	25-Mar-13	22-Apr-13	70.0
68	CA1417783	25-Mar-13	22-Apr-13	70.5
69	CA1417629	25-Mar-13	22-Apr-13	59.5
70	CA1417630	25-Mar-13	22-Apr-13	63.5
71	CA1417632	25-Mar-13	22-Apr-13	61.0
72	CA1417633	25-Mar-13	22-Apr-13	59.0
73	CA1417635	25-Mar-13	22-Apr-13	60.5
74	CA1417636	25-Mar-13	22-Apr-13	57.0
75	CA1417641	25-Mar-13	22-Apr-13	63.5
76	CA1417642	25-Mar-13	22-Apr-13	67.0
77	CA1417644	25-Mar-13	22-Apr-13	64.0
78	CA1417645	25-Mar-13	22-Apr-13	67.0
79	CA1417650	25-Mar-13	22-Apr-13	65.0
80	CA1417651	25-Mar-13	22-Apr-13	64.5
81	CA1417653	25-Mar-13	22-Apr-13	62.0
82	CA1417654	25-Mar-13	22-Apr-13	63.0
83	CA1417656	25-Mar-13	22-Apr-13	63.5
84	CA1417657	25-Mar-13	22-Apr-13	62.5
85	CA1417659	25-Mar-13	22-Apr-13	65.5
86	CA1417660	25-Mar-13	22-Apr-13	74.0
87	CA1417620	25-Mar-13	22-Apr-13	57.0
88	CA1417621	25-Mar-13	22-Apr-13	63.0

89	CA1417623	25-Mar-13	22-Apr-13	57.5
90	CA1417624	25-Mar-13	22-Apr-13	61.5
91	CA1417626	25-Mar-13	22-Apr-13	56.5
92	CA1417627	25-Mar-13	22-Apr-13	58.5

Base slab - B3-1 & B4-1

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1417244	7-Mar-13	4-Apr-13	65.0
2	CA1417245	7-Mar-13	4-Apr-13	63.0
3	CA1417250	7-Mar-13	4-Apr-13	64.5
4	CA1417251	7-Mar-13	4-Apr-13	64.0
5	CA1417259	7-Mar-13	4-Apr-13	67.0
6	CA1417260	7-Mar-13	4-Apr-13	66.0
7	CA1417220	7-Mar-13	4-Apr-13	64.5
8	CA1417221	7-Mar-13	4-Apr-13	62.0
9	CA1417226	7-Mar-13	4-Apr-13	68.0
10	CA1417227	7-Mar-13	4-Apr-13	65.0
11	CA1417229	7-Mar-13	4-Apr-13	75.0
12	CA1417230	7-Mar-13	4-Apr-13	70.5
13	CA1417211	7-Mar-13	4-Apr-13	61.5
14	CA1417212	7-Mar-13	4-Apr-13	60.5
15	CA1417214	7-Mar-13	4-Apr-13	62.5
16	CA1417215	7-Mar-13	4-Apr-13	65.5
17	CA1417217	7-Mar-13	4-Apr-13	63.5
18	CA1417218	7-Mar-13	4-Apr-13	61.5
19	CA1417202	7-Mar-13	4-Apr-13	65.0
20	CA1417203	7-Mar-13	4-Apr-13	65.5
21	CA1417205	7-Mar-13	4-Apr-13	61.5
22	CA1417206	7-Mar-13	4-Apr-13	63.0
23	CA1417208	7-Mar-13	4-Apr-13	66.0
24	CA1417209	7-Mar-13	4-Apr-13	67.0
25	CA1417301	7-Mar-13	4-Apr-13	66.5
26	CA1417302	7-Mar-13	4-Apr-13	67.5
27	CA1417304	7-Mar-13	4-Apr-13	69.5
28	CA1417305	7-Mar-13	4-Apr-13	70.0
29	CA1417310	7-Mar-13	4-Apr-13	66.5
30	CA1417311	7-Mar-13	4-Apr-13	68.0
31	CA1417274	7-Mar-13	4-Apr-13	66.0
32	CA1417275	7-Mar-13	4-Apr-13	63.0
33	CA1417277	7-Mar-13	4-Apr-13	66.5
34	CA1417278	7-Mar-13	4-Apr-13	64.5
35	CA1417280	7-Mar-13	4-Apr-13	67.5
36	CA1417281	7-Mar-13	4-Apr-13	67.5
37	CA1417232	7-Mar-13	4-Apr-13	74.0
38	CA1417233	7-Mar-13	4-Apr-13	76.0
39	CA1417238	7-Mar-13	4-Apr-13	65.5
40	CA1417239	7-Mar-13	4-Apr-13	68.5
41	CA1417241	7-Mar-13	4-Apr-13	63.0

42	CA1417242	7-Mar-13	4-Apr-13	65.0
43	CA1417283	7-Mar-13	4-Apr-13	69.5
44	CA1417284	7-Mar-13	4-Apr-13	66.5
45	CA1417292	7-Mar-13	4-Apr-13	66.0
46	CA1417293	7-Mar-13	4-Apr-13	67.0
47	CA1417295	7-Mar-13	4-Apr-13	64.5
48	CA1417296	7-Mar-13	4-Apr-13	68.0
49	CA1417253	7-Mar-13	4-Apr-13	65.5
50	CA1417254	7-Mar-13	4-Apr-13	65.0
51	CA1417256	7-Mar-13	4-Apr-13	63.0
52	CA1417257	7-Mar-13	4-Apr-13	64.0
53	CA1417268	7-Mar-13	4-Apr-13	66.5
54	CA1417269	7-Mar-13	4-Apr-13	67.0
55	CA1417307	7-Mar-13	4-Apr-13	68.0
56	CA1417308	7-Mar-13	4-Apr-13	66.5
57	CA1417319	7-Mar-13	4-Apr-13	66.0
58	CA1417320	7-Mar-13	4-Apr-13	67.5
59	CA1417322	7-Mar-13	4-Apr-13	64.5
60	CA1417323	7-Mar-13	4-Apr-13	63.5
61	CA1417223	7-Mar-13	4-Apr-13	69.5
62	CA1417224	7-Mar-13	4-Apr-13	69.5
63	CA1417235	7-Mar-13	4-Apr-13	63.5
64	CA1417236	7-Mar-13	4-Apr-13	62.0
65	CA1417247	7-Mar-13	4-Apr-13	65.0
66	CA1417248	7-Mar-13	4-Apr-13	63.5
67	CA1417313	7-Mar-13	4-Apr-13	64.0
68	CA1417314	7-Mar-13	4-Apr-13	63.5
69	CA1417316	7-Mar-13	4-Apr-13	65.0
70	CA1417317	7-Mar-13	4-Apr-13	65.5
71	CA1417286	7-Mar-13	4-Apr-13	67.0
72	CA1417287	7-Mar-13	4-Apr-13	66.0
73	CA1417289	7-Mar-13	4-Apr-13	65.0
74	CA1417290	7-Mar-13	4-Apr-13	67.0
75	CA1417298	7-Mar-13	4-Apr-13	68.0
76	CA1417299	7-Mar-13	4-Apr-13	64.0
77	CA1417262	7-Mar-13	4-Apr-13	66.5
78	CA1417263	7-Mar-13	4-Apr-13	68.5
79	CA1417265	7-Mar-13	4-Apr-13	71.5
80	CA1417266	7-Mar-13	4-Apr-13	70.5
81	CA1417271	7-Mar-13	4-Apr-13	67.0
82	CA1417272	7-Mar-13	4-Apr-13	68.5

Base slab - B5

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1417984	8-Apr-13	6-May-13	73.5
2	CA1417985	8-Apr-13	6-May-13	72.0
3	CA1417987	8-Apr-13	6-May-13	71.5
4	CA1417988	8-Apr-13	6-May-13	69.5
5	CA1417993	8-Apr-13	6-May-13	75.0
6	CA1417994	8-Apr-13	6-May-13	74.5
7	CA1417002	8-Apr-13	6-May-13	68.0
8	CA1417003	8-Apr-13	6-May-13	72.0
9	CA1417005	8-Apr-13	6-May-13	73.0
10	CA1417006	8-Apr-13	6-May-13	74.0
11	CA1417996	8-Apr-13	6-May-13	72.5
12	CA1417997	8-Apr-13	6-May-13	73.5
13	CA1417011	8-Apr-13	6-May-13	72.5
14	CA1417012	8-Apr-13	6-May-13	72.0
15	CA1417014	8-Apr-13	6-May-13	68.5
16	CA1417015	8-Apr-13	6-May-13	68.0
17	CA1417017	8-Apr-13	6-May-13	69.5
18	CA1417018	8-Apr-13	6-May-13	71.0
19	CA1417020	8-Apr-13	6-May-13	69.0
20	CA1417021	8-Apr-13	6-May-13	67.0
21	CA1417023	8-Apr-13	6-May-13	69.5
22	CA1417024	8-Apr-13	6-May-13	67.0
23	CA1417029	8-Apr-13	6-May-13	68.0
24	CA1417030	8-Apr-13	6-May-13	69.5
25	CA1417945	8-Apr-13	6-May-13	72.0
26	CA1417946	8-Apr-13	6-May-13	72.5
27	CA1417948	8-Apr-13	6-May-13	71.0
28	CA1417949	8-Apr-13	6-May-13	75.5
29	CA1417951	8-Apr-13	6-May-13	72.0
30	CA1417952	8-Apr-13	6-May-13	73.0
31	CA1417966	8-Apr-13	6-May-13	65.0
32	CA1417967	8-Apr-13	6-May-13	64.5
33	CA1417972	8-Apr-13	6-May-13	71.0
34	CA1417973	8-Apr-13	6-May-13	70.0
35	CA1417975	8-Apr-13	6-May-13	70.0
36	CA1417976	8-Apr-13	6-May-13	69.5
37	CA1417954	8-Apr-13	6-May-13	61.0
38	CA1417955	8-Apr-13	6-May-13	66.5
39	CA1417957	8-Apr-13	6-May-13	65.5
40	CA1417958	8-Apr-13	6-May-13	62.5
41	CA1417963	8-Apr-13	6-May-13	65.5
42	CA1417964	8-Apr-13	6-May-13	67.0

43	CA1417068	8-Apr-13	6-May-13	72.0
44	CA1417069	8-Apr-13	6-May-13	56.5
45	CA1417077	8-Apr-13	6-May-13	65.5
46	CA1417078	8-Apr-13	6-May-13	69.5
47	CA1417053	8-Apr-13	6-May-13	46.0
48	CA1417054	8-Apr-13	6-May-13	46.5
49	CA1417056	8-Apr-13	6-May-13	48.0
50	CA1417057	8-Apr-13	6-May-13	41.0
51	CA1417062	8-Apr-13	6-May-13	44.5
52	CA1417063	8-Apr-13	6-May-13	46.0
53	CA1417032	8-Apr-13	6-May-13	68.0
54	CA1417033	8-Apr-13	6-May-13	70.0
55	CA1417038	8-Apr-13	6-May-13	68.5
56	CA1417039	8-Apr-13	6-May-13	68.5
57	CA1417041	8-Apr-13	6-May-13	68.5
58	CA1417042	8-Apr-13	6-May-13	70.5

Base slab - B6

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1175470	5-Aug-13	2-Sep-13	60.0
2	CA1175479	5-Aug-13	2-Sep-13	66.0
3	CA1175494	5-Aug-13	2-Sep-13	59.0
4	CA1175521	5-Aug-13	2-Sep-13	60.0
5	CA1175542	5-Aug-13	2-Sep-13	64.5
6	CA1175471	5-Aug-13	2-Sep-13	57.5
7	CA1175480	5-Aug-13	2-Sep-13	63.5
8	CA1175495	5-Aug-13	2-Sep-13	58.5
9	CA1175522	5-Aug-13	2-Sep-13	59.5
10	CA1175543	5-Aug-13	2-Sep-13	60.5
11	CA1175452	5-Aug-13	2-Sep-13	57.5
12	CA1175464	5-Aug-13	2-Sep-13	54.5
13	CA1175473	5-Aug-13	2-Sep-13	58.5
14	CA1175515	5-Aug-13	2-Sep-13	65.5
15	CA1175524	5-Aug-13	2-Sep-13	58.5
16	CA1175527	5-Aug-13	2-Sep-13	58.0
17	CA1175539	5-Aug-13	2-Sep-13	57.0
18	CA1175545	5-Aug-13	2-Sep-13	58.5
19	CA1175446	5-Aug-13	2-Sep-13	57.0
20	CA1175476	5-Aug-13	2-Sep-13	61.5
21	CA1175485	5-Aug-13	2-Sep-13	58.5
22	CA1175488	5-Aug-13	2-Sep-13	58.5
23	CA1175449	5-Aug-13	2-Sep-13	55.0
24	CA1175500	5-Aug-13	2-Sep-13	63.0
25	CA1175503	5-Aug-13	2-Sep-13	59.5
26	CA1175509	5-Aug-13	2-Sep-13	65.0
27	CA1175453	5-Aug-13	2-Sep-13	57.5
28	CA1175465	5-Aug-13	2-Sep-13	55.5
29	CA1175474	5-Aug-13	2-Sep-13	59.0
30	CA1175516	5-Aug-13	2-Sep-13	67.5
31	CA1175525	5-Aug-13	2-Sep-13	57.5
32	CA1175528	5-Aug-13	2-Sep-13	57.0
33	CA1175540	5-Aug-13	2-Sep-13	57.0
34	CA1175546	5-Aug-13	2-Sep-13	60.5
35	CA1175447	5-Aug-13	2-Sep-13	52.5
36	CA1175477	5-Aug-13	2-Sep-13	65.0
37	CA1175486	5-Aug-13	2-Sep-13	60.0
38	CA1175489	5-Aug-13	2-Sep-13	60.0
39	CA1175450	5-Aug-13	2-Sep-13	57.0
40	CA1175501	5-Aug-13	2-Sep-13	60.0
41	CA1175504	5-Aug-13	2-Sep-13	59.5
42	CA1175510	5-Aug-13	2-Sep-13	68.0

43	CA1175452	5-Aug-13	2-Sep-13	57.5
44	CA1175464	5-Aug-13	2-Sep-13	54.5
45	CA1175473	5-Aug-13	2-Sep-13	58.5
46	CA1175515	5-Aug-13	2-Sep-13	65.5
47	CA1175524	5-Aug-13	2-Sep-13	58.5
48	CA1175527	5-Aug-13	2-Sep-13	58.0
49	CA1175446	5-Aug-13	2-Sep-13	57.0
50	CA1175539	5-Aug-13	2-Sep-13	57.0
51	CA1175545	5-Aug-13	2-Sep-13	58.5
52	CA1175476	5-Aug-13	2-Sep-13	61.5
53	CA1175485	5-Aug-13	2-Sep-13	58.5
54	CA1175488	5-Aug-13	2-Sep-13	58.5
55	CA1175449	5-Aug-13	2-Sep-13	55.0
56	CA1175500	5-Aug-13	2-Sep-13	63.0
57	CA1175503	5-Aug-13	2-Sep-13	59.5
58	CA1175509	5-Aug-13	2-Sep-13	65.0
59	CA1175453	5-Aug-13	2-Sep-13	57.5
60	CA1175465	5-Aug-13	2-Sep-13	55.5
61	CA1175474	5-Aug-13	2-Sep-13	59.0
62	CA1175516	5-Aug-13	2-Sep-13	67.5
63	CA1175525	5-Aug-13	2-Sep-13	57.5
64	CA1175528	5-Aug-13	2-Sep-13	57.0
65	CA1175447	5-Aug-13	2-Sep-13	52.5
66	CA1175540	5-Aug-13	2-Sep-13	57.0
67	CA1175546	5-Aug-13	2-Sep-13	60.5
68	CA1175477	5-Aug-13	2-Sep-13	65.0
69	CA1175486	5-Aug-13	2-Sep-13	60.0
70	CA1175489	5-Aug-13	2-Sep-13	60.0
71	CA1175450	5-Aug-13	2-Sep-13	57.0
72	CA1175501	5-Aug-13	2-Sep-13	60.0
73	CA1175504	5-Aug-13	2-Sep-13	59.5
74	CA1175510	5-Aug-13	2-Sep-13	68.0

Base slab - B7

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1322013	27-Dec-13	24-Jan-14	58.5
2	CA1322017	27-Dec-13	24-Jan-14	62.0
3	CA1175981	27-Dec-13	24-Jan-14	56.5
4	CA1175977	27-Dec-13	24-Jan-14	72.0
5	CA1175978	27-Dec-13	24-Jan-14	71.0
6	CA1175980	27-Dec-13	24-Jan-14	54.5
7	CA1175990	27-Dec-13	24-Jan-14	51.0
8	CA1322004	27-Dec-13	24-Jan-14	59.5
9	CA1322005	27-Dec-13	24-Jan-14	56.0
10	CA1175959	27-Dec-13	24-Jan-14	71.5
11	CA1175960	27-Dec-13	24-Jan-14	72.5
12	CA175962	27-Dec-13	24-Jan-14	61.5
13	CA1175963	27-Dec-13	24-Jan-14	73.5
14	CA1175965	27-Dec-13	24-Jan-14	74.5
15	CA1175966	27-Dec-13	24-Jan-14	72.5
16	CA1175968	27-Dec-13	24-Jan-14	73.0
17	CA1175969	27-Dec-13	24-Jan-14	72.0
18	CA1175971	27-Dec-13	24-Jan-14	72.5
19	CA1175972	27-Dec-13	24-Jan-14	69.5
20	CA1175974	27-Dec-13	24-Jan-14	78.0
21	CA1175975	27-Dec-13	24-Jan-14	76.0
22	CA1175926	27-Dec-13	24-Jan-14	74.5
23	CA1175927	27-Dec-13	24-Jan-14	72.5
24	CA1175932	27-Dec-13	24-Jan-14	71.0
25	CA1175933	27-Dec-13	24-Jan-14	72.5
26	CA1175938	27-Dec-13	24-Jan-14	60.5
27	CA1175939	27-Dec-13	24-Jan-14	58.5
28	CA1175872	27-Dec-13	24-Jan-14	58.5
29	CA1175873	27-Dec-13	24-Jan-14	58.0
30	CA1175875	27-Dec-13	24-Jan-14	60.0
31	CA1175876	27-Dec-13	24-Jan-14	58.5
32	CA1175878	27-Dec-13	24-Jan-14	60.0
33	CA1175879	27-Dec-13	24-Jan-14	56.0
34	CA1175881	27-Dec-13	24-Jan-14	58.5
35	CA1175882	27-Dec-13	24-Jan-14	59.0
36	CA1175884	27-Dec-13	24-Jan-14	60.0
37	CA1175885	27-Dec-13	24-Jan-14	59.0
38	CA1175887	27-Dec-13	24-Jan-14	57.0
39	CA1175888	27-Dec-13	24-Jan-14	55.5
40	CA1175911	27-Dec-13	24-Jan-14	60.5
41	CA1175912	27-Dec-13	24-Jan-14	58.0

42	CA1175917	27-Dec-13	24-Jan-14	78.5
43	CA1175918	27-Dec-13	24-Jan-14	78.0
44	CA1175923	27-Dec-13	24-Jan-14	66.0
45	CA1175924	27-Dec-13	24-Jan-14	76.5
46	CA1175893	27-Dec-13	24-Jan-14	60.5
47	CA1175894	27-Dec-13	24-Jan-14	57.0
48	CA1175899	27-Dec-13	24-Jan-14	59.0
49	CA1175900	27-Dec-13	24-Jan-14	59.0
50	CA1175905	27-Dec-13	24-Jan-14	57.5
51	CA1175906	27-Dec-13	24-Jan-14	57.0
52	CA1175944	27-Dec-13	24-Jan-14	63.5
53	CA1175945	27-Dec-13	24-Jan-14	64.0
54	CA1175950	27-Dec-13	24-Jan-14	60.0
55	CA1175951	27-Dec-13	24-Jan-14	59.5
56	CA1175956	27-Dec-13	24-Jan-14	60.0
57	CA1175957	27-Dec-13	24-Jan-14	60.5
58	CA1322010	27-Dec-13	24-Jan-14	58.0
59	CA1322011	27-Dec-13	24-Jan-14	60.0
60	CA1175982	27-Dec-13	24-Jan-14	57.0
61	CA1175983	27-Dec-13	24-Jan-14	76.5
62	CA1175985	27-Dec-13	24-Jan-14	73.0
63	CA1175986	27-Dec-13	24-Jan-14	74.0
64	CA1175988	27-Dec-13	24-Jan-14	73.0
65	CA1175989	27-Dec-13	24-Jan-14	54.0
66	CA1175908	27-Dec-13	24-Jan-14	57.0
67	CA1175909	27-Dec-13	24-Jan-14	59.0
68	CA1175914	27-Dec-13	24-Jan-14	68.5
69	CA1175915	27-Dec-13	24-Jan-14	70.0
70	CA1175920	27-Dec-13	24-Jan-14	74.0
71	CA1175921	27-Dec-13	24-Jan-14	78.0
72	CA1175890	27-Dec-13	24-Jan-14	60.0
73	CA1175891	27-Dec-13	24-Jan-14	57.5
74	CA1175896	27-Dec-13	24-Jan-14	62.0
75	CA1175897	27-Dec-13	24-Jan-14	60.5
76	CA1175902	27-Dec-13	24-Jan-14	59.5
77	CA1175903	27-Dec-13	24-Jan-14	57.0
78	CA1322007	27-Dec-13	24-Jan-14	62.0
79	CA1322008	27-Dec-13	24-Jan-14	60.0
80	CA1175929	27-Dec-13	24-Jan-14	69.0
81	CA1175930	27-Dec-13	24-Jan-14	71.5
82	CA1175935	27-Dec-13	24-Jan-14	57.5
83	CA1175936	27-Dec-13	24-Jan-14	63.0
84	CA1175941	27-Dec-13	24-Jan-14	57.5
85	CA1175942	27-Dec-13	24-Jan-14	59.0
86	CA1175947	27-Dec-13	24-Jan-14	71.0
87	CA1175948	27-Dec-13	24-Jan-14	63.0

88	CA1175953	27-Dec-13	24-Jan-14	61.0
89	CA1175954	27-Dec-13	24-Jan-14	60.0
90	CA1175992	27-Dec-13	24-Jan-14	56.5
91	CA1175993	27-Dec-13	24-Jan-14	56.5
92	CA1175995	27-Dec-13	24-Jan-14	53.0
93	CA1175996	27-Dec-13	24-Jan-14	52.0
94	CA1175998	27-Dec-13	24-Jan-14	57.0
95	CA1175999	27-Dec-13	24-Jan-14	56.0
96	CA1322001	27-Dec-13	24-Jan-14	56.0
97	CA1322002	27-Dec-13	24-Jan-14	54.5

Base slab - B8 & B9

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1322154	4-Jan-14	1-Feb-14	70.5
2	CA1322155	4-Jan-14	1-Feb-14	66.5
3	CA1322157	4-Jan-14	1-Feb-14	69.0
4	CA1322158	4-Jan-14	1-Feb-14	68.5
5	CA1322160	4-Jan-14	1-Feb-14	64.5
6	CA1322161	4-Jan-14	1-Feb-14	63.5
7	CA1322163	4-Jan-14	1-Feb-14	70.5
8	CA1322164	4-Jan-14	1-Feb-14	66.5
9	CA1322166	4-Jan-14	1-Feb-14	69.0
10	CA1322167	4-Jan-14	1-Feb-14	68.5
11	CA1322184	4-Jan-14	1-Feb-14	64.5
12	CA1322185	4-Jan-14	1-Feb-14	63.5
13	CA1322115	4-Jan-14	1-Feb-14	64.5
14	CA1322116	4-Jan-14	1-Feb-14	63.5
15	CA1322118	4-Jan-14	1-Feb-14	57.0
16	CA1322119	4-Jan-14	1-Feb-14	55.5
17	CA1322121	4-Jan-14	1-Feb-14	63.5
18	CA1322122	4-Jan-14	1-Feb-14	63.0
19	CA1322124	4-Jan-14	1-Feb-14	63.0
20	CA1322125	4-Jan-14	1-Feb-14	63.5
21	CA1322127	4-Jan-14	1-Feb-14	64.5
22	CA1322128	4-Jan-14	1-Feb-14	63.5
23	CA1322130	4-Jan-14	1-Feb-14	63.5
24	CA1322131	4-Jan-14	1-Feb-14	62.5
25	CA1322133	4-Jan-14	1-Feb-14	67.0
26	CA1322134	4-Jan-14	1-Feb-14	68.5
27	CA1322136	4-Jan-14	1-Feb-14	66.5
28	CA1322137	4-Jan-14	1-Feb-14	65.5
29	CA1322139	4-Jan-14	1-Feb-14	59.5
30	CA1322140	4-Jan-14	1-Feb-14	60.0
31	CA1322142	4-Jan-14	1-Feb-14	64.5
32	CA1322143	4-Jan-14	1-Feb-14	63.0
33	CA1322145	4-Jan-14	1-Feb-14	66.0
34	CA1322146	4-Jan-14	1-Feb-14	61.5
35	CA1322148	4-Jan-14	1-Feb-14	64.0
36	CA1322149	4-Jan-14	1-Feb-14	63.5
37	CA1322151	4-Jan-14	1-Feb-14	66.5
38	CA1322152	4-Jan-14	1-Feb-14	62.5
39	CA1322169	4-Jan-14	1-Feb-14	65.5
40	CA1322170	4-Jan-14	1-Feb-14	65.5
41	CA1322172	4-Jan-14	1-Feb-14	66.0
42	CA1322173	4-Jan-14	1-Feb-14	65.5

43	CA1322175	4-Jan-14	1-Feb-14	61.5
44	CA1322176	4-Jan-14	1-Feb-14	61.5
45	CA1322178	4-Jan-14	1-Feb-14	66.0
46	CA1322179	4-Jan-14	1-Feb-14	64.5
47	CA1322181	4-Jan-14	1-Feb-14	67.5
48	CA1322182	4-Jan-14	1-Feb-14	67.0
49	CA1322187	4-Jan-14	1-Feb-14	68.5
50	CA1322188	4-Jan-14	1-Feb-14	63.0
51	CA1322091	4-Jan-14	1-Feb-14	65.5
52	CA1322092	4-Jan-14	1-Feb-14	65.5
53	CA1322094	4-Jan-14	1-Feb-14	66.0
54	CA1322095	4-Jan-14	1-Feb-14	67.5
55	CA1322097	4-Jan-14	1-Feb-14	65.5
56	CA1322098	4-Jan-14	1-Feb-14	65.0
57	CA1322100	4-Jan-14	1-Feb-14	61.5
58	CA1322101	4-Jan-14	1-Feb-14	64.0
59	CA1322103	4-Jan-14	1-Feb-14	62.5
60	CA1322104	4-Jan-14	1-Feb-14	61.0
61	CA1322106	4-Jan-14	1-Feb-14	62.0
62	CA1322107	4-Jan-14	1-Feb-14	66.5
63	CA1322109	4-Jan-14	1-Feb-14	63.5
64	CA1322110	4-Jan-14	1-Feb-14	61.0
65	CA1322112	4-Jan-14	1-Feb-14	62.5
66	CA1322113	4-Jan-14	1-Feb-14	64.5
67	CA1322109	4-Jan-14	1-Feb-14	65.5
68	CA1322020	4-Jan-14	1-Feb-14	63.5
69	CA1322022	4-Jan-14	1-Feb-14	67.0
70	CA1322023	4-Jan-14	1-Feb-14	63.5
71	CA1322025	4-Jan-14	1-Feb-14	62.5
72	CA1322026	4-Jan-14	1-Feb-14	66.0
73	CA1322028	4-Jan-14	1-Feb-14	62.5
74	CA1322029	4-Jan-14	1-Feb-14	64.5
75	CA1322031	4-Jan-14	1-Feb-14	64.5
76	CA1322032	4-Jan-14	1-Feb-14	63.5
77	CA1322034	4-Jan-14	1-Feb-14	63.5
78	CA1322035	4-Jan-14	1-Feb-14	61.5
79	CA1322037	4-Jan-14	1-Feb-14	63.0
80	CA1322038	4-Jan-14	1-Feb-14	65.0
81	CA1322040	4-Jan-14	1-Feb-14	67.5
82	CA1322041	4-Jan-14	1-Feb-14	66.5
83	CA1322043	4-Jan-14	1-Feb-14	66.5
84	CA1322044	4-Jan-14	1-Feb-14	61.0
85	CA1322046	4-Jan-14	1-Feb-14	61.0
86	CA1322047	4-Jan-14	1-Feb-14	60.5
87	CA1322049	4-Jan-14	1-Feb-14	62.5
88	CA1322050	4-Jan-14	1-Feb-14	63.0

89	CA1322052	4-Jan-14	1-Feb-14	60.0
90	CA1322053	4-Jan-14	1-Feb-14	65.0
91	CA1322055	4-Jan-14	1-Feb-14	62.0
92	CA1322056	4-Jan-14	1-Feb-14	64.0
93	CA1322058	4-Jan-14	1-Feb-14	62.0
94	CA1322059	4-Jan-14	1-Feb-14	64.5
95	CA1322061	4-Jan-14	1-Feb-14	62.0
96	CA1322062	4-Jan-14	1-Feb-14	61.5
97	CA1322064	4-Jan-14	1-Feb-14	62.5
98	CA1322065	4-Jan-14	1-Feb-14	62.5
99	CA1322067	4-Jan-14	1-Feb-14	59.0
100	CA1322068	4-Jan-14	1-Feb-14	62.5
101	CA1322070	4-Jan-14	1-Feb-14	62.0
102	CA1322071	4-Jan-14	1-Feb-14	65.0
103	CA1322073	4-Jan-14	1-Feb-14	51.5
104	CA1322074	4-Jan-14	1-Feb-14	54.0
105	CA1322076	4-Jan-14	1-Feb-14	51.5
106	CA1322077	4-Jan-14	1-Feb-14	54.0
107	CA1322079	4-Jan-14	1-Feb-14	59.0
108	CA1322080	4-Jan-14	1-Feb-14	58.5
109	CA1322082	4-Jan-14	1-Feb-14	63.0
110	CA1322083	4-Jan-14	1-Feb-14	60.5
111	CA1322085	4-Jan-14	1-Feb-14	63.0
112	CA1322086	4-Jan-14	1-Feb-14	64.0
113	CA1322088	4-Jan-14	1-Feb-14	64.0
114	CA1322089	4-Jan-14	1-Feb-14	62.0

Shaft A Reinstatement - Roof Slab

No.	Concrete Cube No.	Date of Cast	Date of Test	Test Result (Mean Compressive strength) (Mpa)
1	CA1852809	23-Nov-15	21-Dec-15	73.5
2	CA1852810	23-Nov-15	21-Dec-15	74.5
3	CA1852813	23-Nov-15	21-Dec-15	75.0
4	CA1852814	23-Nov-15	21-Dec-15	72.5
5	CA1852817	23-Nov-15	21-Dec-15	74.0
6	CA1852818	23-Nov-15	21-Dec-15	73.0
7	CA1852821	23-Nov-15	21-Dec-15	75.0
8	CA1852822	23-Nov-15	21-Dec-15	74.5
9	CA1852825	23-Nov-15	21-Dec-15	78.5
10	CA1852826	23-Nov-15	21-Dec-15	82.0
11	CA1852829	23-Nov-15	21-Dec-15	68.5
12	CA1852830	23-Nov-15	21-Dec-15	80.5
13	CA1852833	23-Nov-15	21-Dec-15	74.0
14	CA1852834	23-Nov-15	21-Dec-15	76.0