Jurong Readymix Concrete Pte Ltd v Crescendas Pte Ltd (formerly known as Tavica Design Pte Ltd)
[2005] SGHC 67

Case Number : Suit 18/2004

Decision Date : 07 April 2005

Tribunal/Court : High Court

Coram : Lai Siu Chiu J

Counsel Name(s) : Joseph Liow and Richard Tan (Straits Law Practice LLC) for the plaintiff; Karam Singh Parmar and Yong Boon On (Tan Kok Quan Partnership) for the defendant

Parties : Jurong Readymix Concrete Pte Ltd — Crescendas Pte Ltd (formerly known as Tavica Design Pte Ltd)

Building and Construction Law – Damages – Defective works – Whether defective works caused by plaintiff's supply of defective concrete or defendant's premature removal of formwork

Building and Construction Law – Damages – Delay in completion – Whether demolition of defective works disrupted sequence of construction

Contract – Breach – Whether plaintiff breached contract by supplying defective concrete

7 April 2005 *Judgment reserved.*

Lai Siu Chiu J:

The facts

1 Jurong Readymix Concrete Pte Ltd (the plaintiff) is a manufacturer and supplier of concrete to the building industry. Crescendas Pte Ltd (the defendant) is a renovation and building contractor which, at the material time, was building a five-storey light industrial building with basement ("the project") at Toh Guan Road East ("the site") for EG Holdings Pte Ltd ("the owner"). Under the letter of award dated 30 October 2001 from the owner, the commencement and completion dates for the project were 1 November 2001 and 31 December 2002 respectively. Construction work actually commenced on or about 1 March 2002. Jurong Consultants Pte Ltd ("the architects") were the architects appointed for the project while the civil and structural engineers were Mtech Consultants ("the consultants"). The defendant's subcontractor for the concrete works was Fukang Technology Development Pte Ltd ("Fukang").

2 By a purchase order dated 18 February 2002 ("the contract"), the defendant engaged the plaintiff to supply and deliver ready-mix Grade 40 concrete for the project. I shall refer to the terms and conditions of the contract later.

3 On 12 and 13 July 2002, which were a Friday and Saturday respectively, the plaintiff delivered ready-mix concrete to the site. The supply on 12 July 2002 was meant for part of the floor slab on the first storey and for the casting of columns at gridlines 2/B, 2/C, 3/A, 4/A, 4/B, 5/A and 5/B ("the first seven columns"). The concrete supplied on 13 July 2002 was meant for the casting of columns at gridlines 1/C, 1/D, 1/E, 2/D, 2/E, 3/C, 3/D ("the last seven columns") and Part C of the first storey slab.

4 On 13 July 2002, the defendant discovered from Fukang that the test cubes cast on the

previous day were still "green", *viz* they had not hardened even though 24 hours had lapsed. The defendant's project manager, Tan Jwee Aik Andrew ("Andrew"), called representatives of the plaintiff to the site for an inspection. They were Ng Kin Choy Gary ("Ng"), Ricky Giam Tee Hock ("Giam") and John Toh Chiew Kian ("Toh"), who were the technical manager, quality control supervisor and plant superintendent respectively, of the plaintiff.

5 According to Andrew, the allowable time from casting before a formwork can be removed was 12 to 24 hours. In respect of the project, 24 hours setting time was stipulated by the consultants. He said the defendant would normally strike (*ie*, dismantle) the formwork 38 hours after casting. Prior to 12 and 13 July 2002, the plaintiff had delivered several batches of concrete to the site that did not have a slow setting problem.

6 On 13 July 2002, Ng inspected the test cubes and indicated that the columns constructed from the batch of concrete in the test cubes should be "ok". Ng advised the defendant to allow more time for the concrete in the columns to harden before removing the formwork. He did not specify the time required. Ng then took away all the plaintiff's test cubes to ascertain the cause of the slow setting. Andrew decided to wait another day before approving Fukang's request to remove the formwork. According to the defendant's senior foreman, Chew Kim Seng, Fukang would usually have three teams consisting of 15 to 18 men per team to erect as well as to strike the formwork. It took four to five men to strike the formwork for one column.

7 On 14 July 2002, Andrew allowed Fukang to remove the formwork on condition that the concrete on the top surface had hardened. Fukang checked and confirmed that the top of the column at gridline 5/B was hard. By then 38 and a half hours had lapsed since the formwork was erected. When Fukang removed the formwork, however, chunks of concrete fell off from the edges and face of the column. Andrew notified Ng that the concrete for column 5/B had not fully set.

8 According to Andrew, on the morning of 15 July 2002, Giam and Toh visited the site again, inspected column 5/B and watched the removal of the formwork for the columns that had been cast for gridlines 2/B, 2/C, 3/A, 4/A, 4/B and 5/A. The six columns appeared to have been properly set and fully hardened. Toh allegedly informed Andrew that the plaintiff would investigate the cause of the slow setting and render a report thereafter. Andrew followed up with a fax to the plaintiff (addressed to Ng and Toh) on the same day, which he copied to the consultants.

9 At about 1.30pm that same day, Andrew approved the removal of the formwork for the columns cast with concrete from the batch of 13 July 2002. In the course of removal by Fukang of columns 1/E and 2/E, Andrew noticed that parts thereof were still moist and soft. Andrew ordered the formwork to be re-erected. He notified Toh and it was agreed that the defendant would remove the formwork for those two columns the following day.

10 On 16 July 2002 at about 9.00am, in the presence of Giam and Toh (according to the defendant), the formwork for columns 1/E and 2/E were removed. The columns appeared to have set. The formwork for columns 1/D and 2/D cast on 13 July 2002 were removed 70 hours after casting, whilst those for columns 1/C, 3/C and 3/D were removed after 82 hours from casting time. The columns appeared to have properly set.

11 Tan Meng Liang ("Tan"), a project engineer of the consultants, orally as well as by letter dated 16 July 2002, expressed his concerns to Andrew on the failure of the columns to set properly. Tan was afraid there would be hidden cracks and loss of compaction in the columns, even in those columns that did not have chunks of concrete falling off. He informed the defendant that the columns should be removed and reconstructed. However, at a site meeting on the same day, the plaintiff

requested the defendant for an opportunity to conduct investigations and/or tests to ascertain the structural integrity of the columns and, where possible, to carry out repair works to the columns which showed cracks or portions of unset concrete. The plaintiff wanted to avoid demolishing the columns. Tan agreed to wait for the plaintiff's proposals before deciding whether to order the removal and reconstruction of the columns. Andrew, who attended the site meeting, recorded the minutes, to which I shall refer later.

12 On 18 July 2002, the plaintiff took core samples from column 5/B and discovered it had cracks. Tan gave his approval by letter dated 19 July 2002 for coring tests to be carried out for the slab as well as for column 5/B. By a letter to the defendant dated 22 July 2002, the plaintiff recommended that column 5/B be demolished. The plaintiff requested that it be allowed to take core samples from the other 13 columns. By then, the plaintiff had engaged Prof Wee Tiong Hua ("Wee") from the Engineering Faculty of the National University of Singapore as its consultant. The plaintiff also engaged Cast Laboratories Pte Ltd ("Cast") to carry out tests.

13 On 23 July 2002, the defendant replied to the plaintiff's request and reminded the plaintiff that acceding to its request would affect the defendant's progress in the project and expose it to liquidated damages (at $5,000 per day for the first 30 days and thereafter at $10,000 per day). The defendant added that it would look to the plaintiff to indemnify it against any cost, loss and damages incurred in rectifying the problem, with the attendant delay and disruption.

14 At a site meeting on 25 July 2002, Wee proposed three types of tests for core samples to be taken from the remaining 13 columns, even though the defendant preferred the less time-consuming option of demolishing and reconstructing the affected columns. Tan acceded to the plaintiff's request, provided the plaintiff substantiated its proposed tests and repairs by a report endorsed by a professional engineer.

15 On the following day, Tan ordered that column 2/E be demolished and reconstructed. It was in such a deteriorated state that he had no confidence in any method of repair.

16 After an inspection of the remaining 12 core samples on 30 July 2002, Wee recommended that five columns, *viz* 1/E, 2/D, 3/D, 4/A and 5/A, be removed and reconstructed because the samples showed the presence of cracks. The defendant by its letter dated 31 July 2002 informed the plaintiff it would demolish the five columns to avoid further delays. Further, the defendant gave notice that unless the plaintiff rendered its report on these five columns by 3 August 2002, the defendant would proceed to demolish and reconstruct the last seven columns.

17 By its letter dated 2 August 2002, the plaintiff informed the defendant that it would be more expedient to demolish the last seven columns immediately. On 3 August 2002, the defendant requested the plaintiff to return the core samples for columns 1/C, 1/D, 2/B, 2/C, 3/A, 3/C and 4/B for safe keeping and future reference; the plaintiff refused. The defendant decided to carry out its own coring tests before demolishing the last seven columns.

18 Despite further requests, the defendant alleged that the plaintiff refused to provide the former with core samples for the last seven columns. Consequently, Fukang, instead of the defendant, engaged AL Technologies (S) Pte Ltd ("AL Technologies") to do coring tests for the last seven columns. Andrew informed the plaintiff accordingly on 16 August 2002.

19 In a letter dated 15 August 2002 to the defendant, the plaintiff claimed the defendant had orally agreed to pay for the demolition and reconstruction of the last seven columns. According to Andrew, this was never conveyed to him and the defendant denied this claim in its letter dated

20 August 2002 to the plaintiff.

20 Core samples taken on 16 and 17 August 2002 from columns 1/C, 1/D, 2/C and 3/C showed cracks. The defendant duly informed the consultants by letter dated 20 August 2002. The defendant then informed the plaintiff that the consultants were still prepared to accept the last seven columns if a professional engineer could certify that the columns were structurally sound. In response, the plaintiff requested to be allowed to inspect the core samples before demolition was carried out. This was followed by a letter dated 23 August 2002 from the plaintiff's solicitors who requested that the plaintiff's expert be allowed to view the core samples taken by the defendant.

21 The defendant agreed, provided the plaintiff's expert, Wee, inspected the core samples as well as the last seven columns on 24 August 2002 at 9.00am. The plaintiff counter-proposed 1.30pm for the inspection as Wee was not free and/or was not available at 9.00am. Although the defendant did not accede to the change of time, Andrew nevertheless informed the plaintiff that the defendant would postpone demolition of the last seven columns until 2.00pm of 24 August 2002. He repeated the defendant's request for inspection of the core samples taken by the plaintiff and for the test reports relating thereto.

22 Demolition of the last seven columns by Fukang commenced in the afternoon of 24 August 2002 and was completed in three weeks. The defendant re-erected all 14 columns by 14 September 2002. Fukang billed the defendant $72,100 for the demolition and reconstruction works.

23 As a result of the delay caused by demolishing and reconstructing the 14 columns, the defendant could not meet the completion date of 31 December 2002; it only completed the project on 9 April 2003. The defendant alleged that it was liable to the owner for liquidated damages in the sum of $830,000 for the delay of 99 days, calculated at $5,000 per day for the first 30 days and thereafter at $10,000 per day from the 31st day onwards.

24 The defendant took the stand that the losses it incurred due to the delay in completion of the project were attributable to the plaintiff's supply of slow-setting concrete. As such, it refused to pay for the concrete supplied by the plaintiff. In the result, the plaintiff commenced these proceedings.

The pleadings

25 On 23 May 2003, the plaintiff filed this suit claiming the sum of $247,856.34 for ready-mix concrete it had supplied to the defendant, less a credit note.

26 In the Defence and Counterclaim, the defendant alleged that the plaintiff had breached the terms and conditions of the contract in supplying the slow-setting concrete on 12 and/or 13 July 2002. It relied on the following additional terms and conditions ("the Additional Terms") of the contract:

(a) Clause 1(a): The plaintiff shall supply and deliver all materials and/or goods strictly in accordance with the relevant authorities and/or consultants' requirements and to the absolute satisfaction of the project consultants and the defendant.

(b) Clause 3(a): All materials, goods and/or equipment supplied by the plaintiff shall be of good and merchantable quality, be reasonably fit for the purposes for which they are required and comply strictly with the statutory requirements or design mix and specifications.

(c) Clause 3(b): Upon receiving notice from the defendant that any or all of the materials, goods and/or equipment do not comply with cl 3(a), the plaintiff will replace the same immediately at its own cost and expenses.

(d) Clause 5(c): The acceptance and endorsement of the plaintiff's delivery order by the defendant's representative will not discharge the plaintiff of any liability for hidden defects, inferior quality, non-compliance with the specifications or a shortfall in the quantity that was not obviously evident at the time of delivery.

(e) Clause 5(d): No payments made under the purchase order shall be deemed to be an acknowledgement that the plaintiff has discharged all its duties under the order and nothing contained therein shall limit the defendant's rights of set-off.

27 The defendant also relied on cl 3.1 of the General Terms and Conditions in the contract, which provided that time was of the essence under the defendant's Work/Purchase order, and on cl 12.0, where the plaintiff provided a warranty to the defendant that the concrete it supplied would be of merchantable quality.

28 The Defence further pleaded that the following were the express or implied terms of the contract:

(a) that the plaintiff would supply concrete that was of good quality and was reasonably fit for the purpose for which it was intended;

(b) that the plaintiff would supply concrete that met and/or complied with the requirements and/or recommendations set out in the relevant codes of practice and/or building authority specifications;

(c) that the defendant would remove the formwork of the structural members within the shortest time following casting as allowed and/or recommended by the relevant codes of practice and/or building authority specifications and/or in accordance with industry practice.

29 The defendant alleged that the concrete that the plaintiff supplied on 12 and 13 July 2002 was defective and/or was not fit for its intended purpose in that it did not sufficiently set to enable the formwork to be removed within 24 hours or within a reasonable time after casting or within the time reasonably expected by the defendant and/or under the contract.

30 The defendant pleaded that the plaintiff had also breached the duty of care which it owed to the defendant in tort. The plaintiff ought to have known that time for the concrete to set sufficiently for the removal of the formwork was of the essence and that the defendant would remove the formwork in which the concrete was cast after the shortest allowable time following casting.

31 Finally, the defendant relied on the doctrine of *res ipsa loquitur* to say that the columns were damaged as a direct consequence of the plaintiff's breach of contract and/or duty of care in tort.

32 The defendant did not dispute the plaintiff's claim but sought to set it off against the loss and damage which the defendant alleged it suffered, totalling $513,080.48. Taking the plaintiff's claim of $247,850.34 into consideration and deducting the same therefrom, the defendant's counterclaim was for the net sum of $352,475.41.

33 In its Reply, the plaintiff asserted that its obligation under cll 6(c)(ii) and 6(c)(iii) of the

Additional Terms was to supply concrete which should comply with the specified compressive strength after a minimum of 28 days curing. The plaintiff maintained that the concrete it supplied complied with those specifications. Clauses 6(c)(ii) and 6(c)(iii) read as follows:

> (ii) Compliance with the specified compressive strength requirement shall be based on results from testing cubes cast for a sampled concrete batch with the number of these cubes recorded on the delivery order(s).
>
> (iii) Should the tested cube strength at 28 days fail to comply with the requirement, the [plaintiff] must liaise and agree with the [defendant] on a suitable method of testing the hardened in-situ concrete, such as (but not limited to) a rebound hammer test, a core test or ultrasonic pulse testing. All costs and expenses incurred for such tests shall be borne by the [plaintiff].

34 The plaintiff denied that it failed to warn and/or advise the defendant of the slow setting time of the concrete. The plaintiff admitted that the concrete supplied on 12 and 13 July 2002 did exhibit slow setting characteristics which were a natural though infrequent occurrence. However, the damage to the 14 columns was not caused by slow-setting concrete but by the defendant's own act of removing the formwork to the columns before the concrete had properly set. The plaintiff alleged that despite being told by Ng to allow more time for the concrete to set prior to the removal of the formwork, the defendant ignored the plaintiff's advice and removed the formwork, thereby causing damage to the columns.

35 It was pleaded that when the defendant informed Ng on 13 July 2002 that the test cubes had not fully set, Ng had advised the defendant that more time should be allowed prior to the removal of the formwork. Ng had also advised the defendant that the particular formwork for the columns should be wrapped in wet gunny sacks to improve the setting time and the strength of the concrete.

36 The plaintiff admitted that it did request the defendant on 2 August 2002 to demolish and reconstruct the last seven columns although it was not in a position to instruct the defendant either to demolish or to retain the same; the decision was solely that of the defendant. (In its submissions, the defendant pounced on this statement in para 62 of the plaintiff's submissions to say that it was tantamount to an admission by the plaintiff.) However, the defendant had unreasonably required the plaintiff to obtain certification from a professional engineer to certify that the last seven columns were structurally sound. The plaintiff was concerned that whilst the defendant was disputing which party was at fault for the alleged defective concrete and/or columns, the defendant did not take any steps to mitigate its potential loss or delay.

37 The plaintiff denied owing the defendant a duty of care in tort and disputed the losses allegedly suffered by the defendant.

The trial

38 As the defendant did not dispute the plaintiff's claim, trial proceeded on the defendant's counterclaim only on the issue of liability. In the event the defendant succeeded on its counterclaim, the quantum thereof would be assessed by the Registrar. For that reason, I dispensed with the evidence of Oon Soon Lee, the defendant's project development manager, who was responsible for computing the defendant's losses of $513,080.48.

39 The defendant's witnesses of fact were Andrew, Tan and the defendant's senior foreman, Chew Kim Seng ("Chew"), who supervised Fukang's workers. The defendant's other witnesses were

their two consultants, Daniel Thomas Connors ("Connors") and Kenneth James Patterson-Kane ("Patterson-Kane"). The three witnesses of fact for the plaintiff were Giam, Toh and Ng while Wee was its expert witness.

The defendant's case

40 When he testified, Andrew[1] placed the blame for the slow-setting concrete and the resultant demolition of the 14 columns solely on the plaintiff. I have in [3] to [22] above generally outlined Andrew's testimony. Andrew's evidence on what transpired at the site on 12 and 13 July 2002 was corroborated by Chew.[2] I turn my attention now to the testimony adduced in cross-examination of Andrew.

41 Andrew denied the suggestion that, on 13 July 2002, he checked the test cubes only after Fukang alerted him to something being amiss. (When he took the stand, Chew said that he, not Andrew, checked the test cubes together with Fukang's workers.) Andrew also denied that the defendant had already removed the formwork for the first seven columns before the plaintiff's representatives came to the site. He further denied Ng had advised him not to strike the formwork until after the latter had reverted on the outcome of the plaintiff's investigation of the test cubes.

42 Whilst he agreed he had ordered the columns to be demolished before Ng reverted on the plaintiff's investigations, Andrew's justification was that the outcome of such investigation was "irrelevant". He explained that Ng had told him that the defendant could strike the formwork after the concrete had hardened. It had indeed hardened when the defendant checked the top surface of the column by striking it with a hammer. Andrew defended his action as being both appropriate and reasonable, even though he did not first check with the superintending officer, who was Tan. He reasoned there was no necessity to check because previously, Tan (who confirmed this) had told him to follow the minimum striking time laid down in the specifications. By "specifications" Andrew meant the Standard Specifications for Construction Works[3] ("the Specifications") of the Jurong Town Corporation, which were incorporated into cl 6 of the Invitation to Quote from the owner to the defendant, dated 1 August 2001. For formwork of columns, the Specifications stipulated one day's setting time. Andrew pointed out that when the test cubes were found to be still "green", this was just 15 hours after they were cast whereas more than 24 hours had lapsed since the formwork was erected.

43 Andrew had also claimed[4] that after he noticed that the concrete for column 5/B had not fully set, he informed Toh. He asserted (corroborated by Chew) that both Toh and Giam were present when the formwork for the first six columns were removed on the mornings of 15 and 16 July 2002. Andrew further denied that when he was questioned by Ng on 16 July 2002 as to why he (Andrew) had struck off the formwork, he had replied that the defendant could not wait any longer.

44 I should point out that the defendant relied on the alleged presence of the plaintiff's two representatives on site on 16 July 2002, for its submission that the plaintiff had approved the removal of the formwork, which appeared to have hardened properly.

45 Andrew claimed it was normal industry practice to remove the formwork at the top of the columns and strike it with a hammer to ascertain whether the concrete had hardened. He acknowledged that the use of a rebound hammer, as advocated by cl 6(c)(iii) of the Additional Terms, was another non-destructive test of the strength of concrete. Re-examined, Andrew said a rebound hammer test would not normally be done as reinforced bars protruded from the top of the columns.

46 Andrew also agreed that the concrete supplied on 13 July 2002 was also used to cast the

floor slab, that it hardened properly and that the formwork was only removed after 28 days.

47 Tan[5] testified he was surprised by the plaintiff's decision to demolish the last seven columns on 2 August 2002 as prior thereto, the plaintiff was against the move. He explained that once concrete had set and hardened, its strength would be 60% to70% of its self-weight, which was more than adequate to support its own weight. He further clarified that ascertaining the strength of concrete (which had to be done in a laboratory) after one day's setting was different from ascertaining when formwork could be removed from a concrete structure.

48 As a result of the plaintiff's supply of defective concrete, Tan said his involvement in the project was prolonged and he billed the defendant for his additional services.

49 Connors, whom I would term a construction management consultant, was engaged by the defendant to render his professional opinion on the time and costs issues involved as a result of the delays to the project due to the defective concrete.

50 Connors[6] reviewed all relevant documents which included the defendant's intended work programme, the change in sequence of construction due to the demolition of the columns, the critical path of work as well as the issue of liquidated damages for delay. He then analysed the 99 days' delay in the completion of the project. Connors also looked into the direct cost of replacing the 14 columns, including testing and professional fees as well as the cost consequence of the delay. He then apportioned liability between the plaintiff and the defendant.

51 Connors' evidence would be material on the issue of liability if I find that the defendant's critical path of work and its sequence of work were indeed affected by the demolition and reconstruction of the 14 columns.

52 The defendant's final witness was Patterson-Kane,[7] a qualified civil engineer whose company offers consultancy services. Patterson-Kane's brief from the defendant was to render his professional opinion on:

(a) whether the concrete supplied by the plaintiff was defective;

(b) the likely causes of the slow setting of the concrete;

(c) the effect of the defective concrete;

(d) the direct cost of the demolition and reconstruction of the affected columns; and

(e) the delay in completing the columns.

53 In determining issue (a) above, Patterson-Kane agreed that the recommended stripping time for vertical formwork to columns was one day. He based his opinion on the Singapore Standard CP 65: Pt 1: 1999 – Code of Practice for Structural Use of Concrete – Design and Construction ("the Code").

54 Patterson-Kane disagreed with the plaintiff's Reply where it was pleaded that the slow setting phenomenon was not uncommon or that concrete with such characteristics was not defective. Based on his 38 years of experience as a consulting engineer, Patterson-Kane opined that such concrete was indeed defective. He further disagreed with the plaintiff's opinion that the columns were defective due to premature de-moulding, pointing out that the affected columns had their formwork removed after more than one day's casting. He noted that columns 1/C and 3/D showed internal

cracks even though the formwork was removed after 80 hours of setting time.

55 On issue (b) in [52] above, Patterson-Kane did not disagree with Wee's suggestion that slow setting could be due to cement particles being too coarse but felt that the coarseness would have to be quite extreme to cause the delay in setting in this case. He felt that the more likely causes were that the constituent materials of the mix and/or the mix proportions were not in compliance with the design mix. Contamination of one of the constituent materials of the concrete mix was another possible cause. However, he himself did not conduct any tests to ascertain the concrete mix.

56 As for the effect of the defective concrete, Patterson-Kane opined it caused the internal cracking in the columns, which was only revealed in tests of the core samples. Such cracking seriously reduced the strength of the columns even if the concrete in those parts between the cracks achieved the specified compressive strength after 28 days. Hence, he formed the view that all 14 columns cast on 12 and 13 July 2002 were unsound.

57 Patterson-Kane estimated $70,000 to be a reasonable sum for the direct costs of the demolition and reconstruction of the columns under issue (d) in [52] above. For issue (e), he was of the view that the defective concrete, together with the subsequent actions and/or failure to act by the plaintiff, delayed the completion of the ground floor columns.

58 In the course of cross-examination, Patterson-Kane agreed that if the defendant knew that the concrete was still soft after 24 hours, more caution should have been exercised before striking the formwork. Similarly, if test cubes were still green after 24 hours, Patterson-Kane agreed with counsel that more caution should have been taken before striking the formwork. Extending the time for the concrete to set was one method that could be adopted. He estimated that the concrete would achieve its final set and become solid five to six hours after casting. He agreed with counsel that the formwork which was partially removed and then put back before the concrete had achieved its final set would not do any good as the damage would already have been done to the column. (This would apply to columns 1/E and 2/E.) However, slow setting of the concrete did not in itself cause cracks as seen in the core samples. Patterson-Kane had taken photographs of the core samples from the various columns and attached them to his report. It was noted and acknowledged by him that some photographs showed no cracks.

59 Patterson-Kane agreed it was only when concrete was solid that its strength could be tested. He was of the view that the actual strength for a column to support its own weight was trivial. In any case, Grade 40 concrete would achieve 60% to 70% of its strength after seven days. Although it was also a non-destructive test like the rebound hammer test, Paterson-Kane did not agree that a Windsor probe test was more accurate than the former.

60 Patterson-Kane opined it was not necessary to ascertain the minimum strength required before the formwork of a column could be struck. However, based on a publication produced by counsel for the plaintiff called *Report of American Concrete Institute*, he agreed that before formwork could be struck, three factors had to be considered, *viz* (a) concrete strength, (b) type of surface of the form, and (c) presence of a release agent. He felt the defendant's method of using a conventional hammer to test the hardness of the concrete at the top of the column was equally acceptable as a rebound hammer test.

The plaintiff's case

61 Giam[8] rebutted Andrew's claim that he was present at the site when the defendant struck the formwork of the columns on 15 and 16 July 2002. Giam pointed out that he was only marginally

involved in the events surrounding the slow-setting concrete. As the plaintiff's quality control supervisor, he was concerned with the quality of the concrete supplied to the defendant. Hence, on Ng's instructions, he checked the plant batching records to see if there was anything wrong with the particular batch of concrete supplied to the defendant. He found nothing amiss in the plaintiff's batching records which would indicate why the concrete supplied on 12 and 13 July 2002 showed slow setting properties. Subsequently, he arranged for Cast to conduct tests on the floor slab and columns cast with the slow-setting concrete. To that end and purpose, he co-ordinated with Andrew on the dates suitable for Cast's personnel to attend at the site. He was not aware of the results of tests conducted by Cast. On the one or two occasions when he was at the site, Giam deposed he was never specifically asked by Andrew for his opinion as to whether the defendant could strike the formwork for any concrete structures nor was he asked to observe the removal of formwork. Giam said he was not qualified to give any such opinion.

62 Cross-examined, Giam explained that as part of the quality control procedure, he would prepare six test cubes for every 100m³ of concrete produced at the plaintiff's plant. This procedure was followed for the concrete delivered to the defendant on 12 and 13 July 2002. In addition, when the supply was delivered, the plaintiff sent its "cube" man to prepare the test cubes on site for the defendant, using concrete samples selected by the defendant. As such, the plaintiff would not know from which delivery truck the concrete samples were drawn. (When Ng testified, he said that as a prudent measure, six samples should be taken from every truckload of concrete, for the test cubes prepared on site.)

63 Giam recalled he had overheard Ng telling Andrew on 13 July 2002 not to strip the formwork. However, nothing was said about waiting for the concrete to first harden. Giam inspected the test cubes at the site on his first visit but did not take them away. He left the site to check the plaintiff's batching records. He extracted the records relating to deliveries to the defendant and passed them onto Ng.

64 Although he was uncertain whether he was on the site on 15 or 16 July 2002, Giam testified he returned to the site to make arrangements for tests to be done on the concrete. By then, the formwork had already been dismantled. Otherwise, the tests could not have been carried out. The first test he arranged was the Windsor probe test. Giam said he co-ordinated two other tests to be conducted on the columns and slabs, *viz* the UPV (ultrasonic pulse velocity) and core tests. He visited the site thrice – first, to look into the defendant's complaint, second, to arrange with Andrew for the three tests to be done and last, to bring onto the site one Willie Kay who had been requested to recommend methods of repair for the columns.

65 In his written testimony, Toh[9] deposed that when he was told of the defendant's complaint on the slow-setting concrete, he went to the site alone on the morning of 13 July 2002 where he met Andrew. He then contacted and requested Ng to come to the site. That same afternoon, Ng, Giam and he met Andrew. Toh deposed that Ng told Andrew not to de-mould the columns while the plaintiff took the test cubes back to study and Andrew had said that he could not wait too long. A day or two later, Toh went back to the site with Ng and Giam to look at the columns in order to decide what course of action to take. When the trio arrived, they noticed that a number of the formwork had been struck. Toh did not involve himself in the discussion that then took place (mostly between Andrew and Ng). He recalled returning to the site on a third occasion to obtain core samples.

66 Toh had a poor memory. Questioned whether he had attended a meeting on16 July 2002, Toh gave a negative answer even though the minutes confirmed his presence.

67 Ng[10] left the plaintiff's employment in June 2003 to become a freelance consultant. Ng

considered himself a concrete specialist as he had been in the concrete business for nine years, had worked as a construction manager and lectured part-time on the subject. He deposed in his affidavit that he was surprised to see on his second site visit (16 July 2002) that the defendant had removed the formwork from four to five columns. When he questioned Andrew, the latter replied that the defendant could not afford to wait any longer and it would proceed to strike off all the formwork.

68 Ng pointed out that the minutes of the site meeting dated 16 July 2002 ([67] above) recorded by Andrew were inaccurate, where it was recorded:[11]

> As for the elements which are verified to be structurally adequate by the tests, [the plaintiff] mentioned that arrangements can be made for a Qualified Person (Professional Engineer) to endorse the structural integrity.

He said the suggestion actually came from the defendant and having seen the consultants' letter dated 26 July 2002,[12] he believed it emanated from Tan. It was in response to this suggestion from the defendant that Ng was prompted to engage the services of Wee to render expert assistance on (a) the condition of the concrete in the floor slab, and (b) to determine whether the 14 columns were structurally sound.

69 Although he disagreed with the way the minutes were drafted, Ng testified he did not write to the defendant to record his objections; he telephoned Andrew instead. He denied counsel's suggestion that the plaintiff[13] had agreed to bear the cost of repair and removal of the columns but subsequently reneged upon realising the full extent of the problem and the high costs involved.

70 Ng explained that the plaintiff on 2 August 2002 agreed to the demolition of the last seven columns because there was then an impasse between the parties *vis a vis* the defendant's insistence on a professional engineer's endorsement for those columns and the plaintiff's inability to furnish the same. He and his general manager, Michael Ho (who has since left the plaintiff's services), were concerned that if the defendant succeeded in putting the blame on the plaintiff, the plaintiff could be liable for any liquidated damages imposed on the defendant for delay in completion. Hence the plaintiff's decision to demolish the last seven columns even though it was satisfied from a visual inspection and from the compressive strength test carried out on core samples, that the concrete in those columns was sound.

71 Cross-examined, Ng revealed that on 13 July 2002 he had noted that all 14 columns had been cast. He climbed up one column that day (which counsel for the defendant disputed) and noted that the concrete was still in its plastic state. When Ng told Andrew not to de-mould until after the concrete had hardened, Andrew expressed his concern that it would affect the defendant's progress. Ng agreed that this was not unexpected as all contractors would be concerned about progress being affected, due to the threat of liquidated damages for delay.

72 Ng testified he sent the six test cubes he took from the site to the plaintiff's admixture supplier WR Grace ("Grace") for testing. Grace's test report,[14] which Ng inadvertently omitted to send to the defendant, showed no overdose of admixture. However, Grace could not ascertain the cause of the slow setting. By the time Grace's test report (dated 6 August 2002) was received by the defendant, it was no longer relevant as the plaintiff had agreed on 2 August 2002 to the replacement of the last seven columns.

73 Ng took issue with the suggestion of Grace in its test report that the slow setting properties of the concrete could be due to contamination and impurities in the raw materials. No tests were carried out to verify this conclusion. The inability of Grace to find out the cause of the slow setting

prompted Ng to seek Wee's assistance.

74 Ng disagreed with the suggestion from counsel (for the defendant) that the plaintiff took inadequate steps to ascertain the cause of the slow setting of the concrete. Although the plaintiff prepared the design mix for the customer, it had to be approved by the customer. (It appeared from Ng's re-examination however, that the defendant did not approve a design mix for the concrete supplied on 12 and 13 July 2002.)

75 Ng testified that the plaintiff also complied with its quality control procedures by doing impurities checks (via random sampling) on its raw materials including sand and aggregates. In addition, the plaintiff received a concrete test report from its concrete supplier, Jurong Cement, and an admixture report from Grace for every batch of admixture supplied by Grace. The reports that Ng received from both suppliers showed no contamination. Ng testified that on 12 July 2002, the plaintiff's plant produced 100m³ of concrete. This was supplied not only to the defendant but to other construction sites. Deliveries to other customers of the plaintiff were not affected by slow setting. This suggested that the problem was not caused by contamination of the raw materials. For that reason, Ng explained he did not warn the defendant as he was unaware of the problem until he received the defendant's complaint on Saturday, 13 July 2002. Ng pointed out that nothing could be done on Sunday, 14 July 2002 although the plaintiff took measures to ensure the slow setting problem did not recur. It was on the afternoon of the following Tuesday (16 July 2002) that Ng returned to the site with Giam and Toh.

76 Shown a photograph of column 5/B by counsel for the defendant (taken on 14 July 2002) which showed uneven hardening, Ng pointed out that the column could have been cast from concrete produced in different batches. This would mean the setting times for the concrete for one column would not be homogeneous and would explain why the photograph showed the bottom portion of column 5/B was still soft when the top portion had hardened. Ng pointed out that one day's casting by the defendant required more than one batch of concrete. The last seven columns would have required about 40m³ of concrete which would be more than one batch produced by the plaintiff. By "batch" he meant deliveries made on the same day. The last seven columns cast on 13 July 2002 were constructed from the second batch of concrete.

77 Ng agreed it was not unreasonable of the defendant (in its letter dated 5 August 2002) to want to conduct tests and take core samples before demolishing the last seven columns; the plaintiff had not provided the defendant with reports of the plaintiff's tests despite the defendant's request. However, Ng recalled that he did return the on-site test cubes to the defendant. Asked for proof by counsel for the defendant, Ng referred to a compression test report on three test cubes done by AL Technologies on 10 August 2002 for the defendant; the cubes were cast on 12 July 2002. I note from the exhibits attached to Wee's affidavit evidence, that two other similar tests were conducted on the defendant's behalf.

78 In re-examination, Ng explained that the plaintiff instructed the defendant to demolish the last seven columns on 2 August 2002 because negotiations had broken down to resolve the issue of responsibility for the costs involved. He added that the plaintiff's initial offer in the meeting on 16 July 2002 to pay for the costs of removal and reconstruction of the first seven columns was a goodwill gesture, even though the plaintiff felt that the problem was due to premature striking of the formwork.

79 Wee's brief from the plaintiff was to establish the cause for the cracks in some of the core samples he had inspected, not to find the cause of the slow setting of the concrete. He was also asked for his opinion on the properties of "good" concrete and whether slow setting would render

concrete "bad".

80 In relation to his brief, Wee[15] deposed he had seen the contract, the results of tests carried out by Cast and AL Technologies and he had made site inspections on 18, 19, 20, 25 and 30 July 2002 as well as 24 August 2002. Wee also referred to the Code (on structural use of concrete) as well as the Singapore Standard CP 23: 2000 – Code of Practice for Formwork. Five UK and American publications were also referred to by Wee for his evidence. Wee also saw the mix designs of the concrete ordered by the defendant (after he had affirmed his affidavit of evidence-in-chief).

81 On setting of concrete generally, Wee explained there were two stages, initial and final. In initial setting, the concrete is poured into formwork or is cast. It should not be disturbed during the initial set stage as otherwise the concrete may crack or void spaces could develop within the concrete. The final set stage of the concrete indicates the onset of mechanical strength. After final setting, concrete becomes rigid. Wee pointed out that slow setting *per se* does not make concrete bad or unsuitable where there is no specified setting time requirement, as in this case.

82 Wee explained that the determinants of whether the concrete was good were: (a) compressive strength at a specified age, (b) workability, and (c) durability. On determinant (a), the strength of concrete referred to its ability to withstand forces imposed on it before it failed. The strength requirement for the defendant's concrete was to be found in cll 6(c)(ii) and 6(c)(iii) of the contract (which terms were set out in [33] above). However, setting time and compressive strength did not have any co-relationship, according to many textbooks.

83 Wee opined that the concrete supplied by the plaintiff on 12 July 2002 was likely to have sufficient strength as:

(a) the core samples when tested by Cast appeared to have met Grade 40 requirements;

(b) the Windsor probe test conducted on the columns taken eight days after casting showed the estimated *in-situ* strength to be relatively high and in all probability, the concrete would have achieved its desired strength after 28 days under cl 6(c)(iii).

84 As for the concrete supplied on 13 July 2002, Wee opined that the test cubes tested by AL Technologies all appeared to meet Grade 40 requirements. His conclusion was supported by the fact that after the first joint inspection, there did not appear to be any further complaints or defects in the concrete that was poured into the first storey slab.

85 Wee deposed that the workability of the concrete was determined by a slump test. If the concrete failed the slump test (which should be done in the presence of the supplier and customer), then the concrete should be rejected.

86 Durability referred to the ability of concrete to resist weathering action, chemical attacks, abrasion or other processes of deterioration. Durability was governed by specifying (a) the minimum cement content, and (b) the maximum water to cement ratio. Wee assumed that the water to cement ratio was met since the concrete supplied on 12 and 13 July 2002 satisfied the strength requirements. His belief was reinforced by the fact that there was no claim *vis-à-vis* the first storey slab.

87 Wee relied on cl 6(c)(iii) to say a rebound hammer test was one of the methods of checking the hardness of concrete. Another non-destructive method was the Windsor probe test. Cross-

examined, he disagreed that a Windsor probe test could not be done without removing the formwork. He pointed out that firing a pin into the concrete to carry out the test could be done via the top of a column, notwithstanding that reinforced bars protrude from that space. Having inspected the columns, Wee opined that the Windsor probe test could still be done notwithstanding the presence of those bars. Although a Windsor probe test essentially tests the hardness of concrete, Wee maintained it could also be used to test the strength of concrete. Crushing cube samples was not the only way to test the strength of concrete.

88 From his visual inspection of the core samples taken from all the columns, Wee gave seven possible causes for the cracks, of which only one was a result of human intrusion. He added that the six natural phenomena were unlikely to be the cause of the cracks. He felt that the more likely cause was disturbance of the concrete while it was in its plastic state, before it had gained sufficient strength.

89 Wee based his view on reports he had received that upon removal of the formwork, the concrete was observed to be still "green". He himself had noted that the formwork of column 5/B had been prematurely removed – the concrete (evidenced in photographs he took) showed scaling and spalling. When formwork from columns is removed too early, the relief of lateral pressure from the formwork coupled with the weight of the concrete causes the concrete to deform laterally thus inducing cracks. This effect is more severe in columns due to the higher overhead load (self-weight) relative to the lateral dimensions. When formwork is removed from concrete that has not sufficiently hardened, the force involved may result in cracks.

90 During cross-examination, Wee agreed that to be Grade 40, concrete must achieve 40 megapascals (with 5% allowance) or more within 28 days. Further, strength development starts from initial setting of the concrete up to and continues after 28 days. Wee agreed that two columns cast from Grade 40 concrete may not have the same strength development, as the design mix and admixtures could be different. If a mix design contained a retardant, that would result in slower strengthening of the concrete. Wee agreed that factors such as (a) overdose of retardant, (b) presence of impurities, and (c) contamination of and/or the poor quality of raw materials could cause slow setting of concrete. It could even be due to contamination during the process of delivery – the delivery truck may not have been washed thoroughly enough so that traces from a previous load of concrete remained.

91 Wee agreed that concrete that failed to perform in accordance with its design mix would be considered defective. He further agreed that building contractors would rely on the timelines stated in the Code ([53] above) to strike concrete after casting even if the contract or purchase orders (as in this case) did not specify strike times. However, Wee disagreed with the suggestion of counsel for the defendant that all concrete made from the same design mix would behave largely in the same way. Neither are strike times determined by the design mix even though maximum strike times for ordinary concrete mixes are specified in the Code.

92 Wee also disagreed with the defendant's case on why the columns cracked. It was put to him that the outer surface of the columns had hardened when the formwork was removed but the concrete inside did not fully set, that the removal of the formwork caused the concrete to "bulge" and cracks then formed.

The issues

93 The issues for determination are:

(a) Did the slow setting of the concrete *per se* cause the cracks in the columns?

(b) Who made the decision to strike the formwork from the columns?

(c) Was the decision to strike the formwork reasonable?

(d) Did the decision to strike the formwork cause the demolition of the 14 columns?

(e) Were the consequential expenses and losses claimed by the defendant in the counterclaim a direct result of that decision?

(f) If the plaintiff was negligent in supplying defective concrete to the defendant, did the latter's acts in striking the formwork when it did constitute a *novus actus interveniens*?

It is necessary to determine issue (f) as the defendant's defence and counterclaim[16] was also framed in tort (see [30] above).

The findings

94 I noted from the evidence that the plaintiff's version of what transpired on 12 and 13 July did not differ significantly from the defendant's save in one material respect, *viz* whether Giam and/or Toh were at the site to inspect the removal of the formwork from the affected columns on 15 and 16 July 2002.

95 When they testified, neither Giam[17] nor Toh[18] could recall being at the site on those days. In his re-examination, it became clear that Giam was unlikely to have been present when the formwork was removed on 16 July 2002. He recalled that at Ng's request, he visited the site once after Andrew complained of the slow-setting cement. The second time he visited the site was on 20 July 2002, in order to co-ordinate the Windsor probe test that was to be conducted by Cast on the core samples.

96 Similarly, Toh could not recall when he visited the site again after the first occasion on 13 July 2002. However, during cross-examination when it was suggested that he had inspected a column that was removed on 15 July 2002, Toh (despite his poor recollection of events) disagreed and said the column had already been removed when he went to the site. Re-examined, Toh recalled visiting the site twice, once, alone, upon receipt of the defendant's complaint and the second occasion was when he accompanied Ng and Giam. Ng had taken away the test cubes on the second visit.

97 In their submissions,[19] the plaintiff pointed out that Toh's testimony contradicted both parties' case. It was common ground that on the first visit to the site by the plaintiff's representatives, Toh was accompanied by Ng and Giam as well as by the defendant's representatives and that Ng took the test cubes back for investigation. The plaintiff pointed out that Toh was clearly confused. Taking their overall testimony into consideration, the plaintiff submitted that neither Giam nor Toh were present when the defendant allegedly removed the formwork on the dates Andrew claimed. It should be noted that Toh testified that he never saw the defendant's letter dated 15 July 2002 wherein it was alleged he had visited the site on 15 July 2002 and inspected column 5/B. Ng, the recipient, explained he did not show the letter to Toh as it related to a management matter which did not concern Toh.

98 The plaintiff further submitted that it would be odd for Andrew, who is a trained engineer, to

seek Toh's approval on removal of the formwork when he knew Toh to be only a coordinator who was not qualified to give approval. When he was cross-examined, Andrew explained that Toh could have consulted Ng in this regard before he gave the defendant the go-ahead to remove the formwork; I disagree. In the light of my earlier assessment (at [66] above) of Toh's testimony, I very much doubt that Toh would proffer advice, let alone that a professionally qualified person like Andrew would accept what a technician like Toh said.

99 It struck me in the course of his cross-examination, that Toh was not a person who could or would make decisions. I formed the view that Toh's involvement was really quite minimal as he had claimed in his affidavit. Consequently, it is highly unlikely, as Andrew had alleged, that Toh would make decisions for the plaintiff let alone the defendant *vis-à-vis* the removal of the formwork. Toh was a person who merely followed the instructions of his superiors. This can be seen from the following evidence:

(a) When he first inspected the test cubes on site and found they were soft to the touch, Toh did not give any advice to Andrew but merely said he would ask the plaintiff's quality control manager, *viz* Ng, to come to the site.

(b) Toh went to the site on a second occasion on the instructions of his superior, Ng, to look at the columns without really knowing the purpose.

100 The plaintiff had criticised the defendant/Andrew for using an ordinary hammer to strike the columns to test for hardness instead of using a rebound hammer. The defendant's consultant Patterson-Kane,[20] however, confirmed usage of an ordinary hammer was an industry practice. So too did Ng when he was cross-examined. Ng had further agreed that striking the concrete with a hammer would be a logical step to take, following his advice to the defendant not to remove any formwork from any columns until the concrete had sufficiently hardened.

101 It was established at the trial that the strength of concrete means its compressive strength, which is measured in megapascals. Measuring strength of concrete in columns called for more than simply striking the column with an ordinary hammer. A rebound hammer test and a Windsor probe test were the recommended methods to test for compressive strength according to Wee. Although Andrew and Tan were aware of these two tests, it appeared they were not used in the industry as a whole and certainly not by the defendant.

102 Contrary to Andrew's denials, I am certain that Fukang's workers did remove the formwork on 13 July 2002 without his knowledge or consent. The reasons therefore as set out in the plaintiff's submissions[21] were quite logical. Fukang would have assumed that after 24 hours, the formwork cast on 12 July 2002 could be struck. Neither Fukang nor the defendant had encountered the problem of slow-setting concrete previously. There was no reason for Fukang to check on the hardness of the concrete of the columns cast on 12 July 2002 before its workers dismantled the formwork. Although Chew claimed under cross-examination that only one team of Fukang's workers removed the formwork on 14 July 2002 from one column, I disbelieve him. It was unlikely that Fukang's remaining workersdid other tasks that day, bearing in mind Chew's testimony that Andrew had told him the formwork could be removed after 48 hours from the date of casting. I am certain Fukang's workers would have dismantled all the formwork from the first seven columns cast on 12 July 2002.

103 Ng had testified that when he first went to the site on 13 July 2002, he had noticed that part of the formwork of two columns had been removed. It must have been in the course of striking the formwork of the two columns when Fukang noticed the concrete was still moist and/or soft that its workers alerted Chew, and in turn, Andrew. The plaintiff's submissions[22] highlighted the fact that

the test cubes (according to Andrew) were 50m away from the related columns. It was unlikely the defendant would have checked the test cubes first, bearing in mind that the test cubes were meant for compressive strength tests scheduled to be conducted on the seventh and 28th day after casting, not to test for setting times.

104 The plaintiff accused Andrew of lying when he said in his letter dated 15 July 2002[23] that:

> As for the casting of the 1st storey slab and 2nd batch of columns on 13/7/2002, we encountered the same problem with numerous soft/moist areas on the slab.

The plaintiff pointed out that a photograph taken on 14 or 15 July 2002[24] of the first storey slab clearly showed footprints in the soft/moist concrete. That meant that Andrew had noticed the slow setting properties of the concrete on the slab. That being the case, Andrew could not have believed (as he claimed) that the slow setting incident on 12 July 2002 was an isolated event. It meant that the concrete supplied on 13 July 2002 had the same problem and Andrew was reckless in using an ordinary hammer to test the hardness of the surface of column 5/B instead of using the Windsor probe test to check its compressive strength.

105 I accept the above submission as being consistent with the evidence before the court. It follows that Andrew should also have waited longer for the columns to harden properly instead of removing their formwork after 40 hours. Granted the defendant was very conscious of the spectacle of liquidated damages should there be a delay in the completion of the project, but this concern did not mean Andrew should have disregarded Ng's express advice not to de-mould the columns. If, as the defendant contended, Ng did not specify a time frame for the formwork to remain in place longer, surely Ng could have been asked but he was not.

106 I note that neither side's experts could state with any certainty the reason for the slow setting of the concrete. Indeed, both Patterson-Kane and Wee were in agreement on the possible causes for the slow setting of the concrete. They only disagreed on whether the slow setting was responsible for the cracks in the columns. It would serve no useful purpose therefore to speculate on which of the possibilities canvassed by both sides could have been the cause for the slow setting phenomenon. I should add that while both Patterson-Kane and Wee discharged their duties as court witnesses under O 40 of the Rules of Court (Cap 322, R 5, 2004 Ed), I found Wee's investigations and findings more thorough.

107 Although taking cube samples from every truck of concrete delivered to the defendant would have been ideal for testing the quality of concrete, it was suggested by the defendant that this was not a practical approach. During Wee's cross-examination, counsel for the defendant revealed that four trucks delivered the first batch of concrete on 12 July 2002; for the second batch delivered on 13 July 2002, more than 50 trucks were involved. Counsel for the defendant said it would have been impossible to take cube samples from every truck. Wee then conceded that the ideal practice was not the common practice, which was to take a random sampling (as Ng had also testified).

108 The 14 columns that were demolished were apparently 9m in height. As counsel for the defendant rightly pointed out to Wee, one column could be cast from concrete delivered by different trucks. If a truck contained contaminated concrete, it meant that a column could be cast with both good and bad concrete. In such a case, counsel for the defendant had suggested to Wee that a Windsor probe test would not be reliable to test the hardness or strength of the concrete as the hardness would vary at different locations of one column.

109 In re-examination however, Wee asserted that more could have been done by the defendant

before demolishing the columns. In a worst-case scenario where the formwork had been removed from a column and chunks of concrete had fallen off, Wee opined that a contractor who was in a hurry to strike the formwork, like the defendant, should have used a Windsor probe test to check the tops of all other remaining columns. At the same time, the contractor should obtain more information from the concrete supplier on the batches of concrete delivered, check his casting records to ascertain which batch of concrete was used to cast which columns and check if he had taken cube samples from every truck.

110 I note that counsel for the defendant did not challenge Wee's testimony that no cracks were found in three of the 14 columns that were demolished. The columns with "good" concrete were 2/B, 3/A and 4/B, according to the core samples taken on 19/20 July as well as 16/17 August 2002. Hence, there was no reason to demolish those columns at all.

111 Although the evidence was inconclusive on the cause of the slow setting of the concrete, the defendant did not dispute the fact that the concrete supplied on 13 July 2002 was also used to lay the first storey floor slabs. The slabs showed no cracks despite slow setting properties. The plaintiff used this fact[25] to support its argument that it was the premature removal of the formwork that caused the cracks in the columns.

112 Even if the plaintiff was negligent in supplying defective concrete to the defendant, if the chain of causation was broken because the cracks in the columns were caused not by the slow-setting concrete but by the defendant' premature striking of the formwork, the doctrine of *novus actus interveniens* would apply to extinguish the plaintiff's liability for the defendant's losses arising out of the breach of duty of care.

113 On the one hand, the plaintiff submitted that the defendant should have delayed striking the formwork of the columns as was done for the floor slab. On the other hand, the defendant contended that it was an express contractual requirement under cll 1(a) and 3(a) ([26] above) of the Additional Terms that the concrete should set within 24 hours.

114 In its final submissions, the defendant pointed out that it did not strike the formwork after 24 hours but much later. The defendant produced a striking schedule[26] for the 14 columns which showed a minimum striking time of 38.5 hours (column 5/B) and a maximum of 82 hours (columns 1/C, 3/C and 3/D. The defendant added that when the test cubes for the first seven columns were checked and found to be green, it was about 15 hours after casting. Hence, the cubes could not be used as a gauge for the required setting times for the columns. The plaintiff however challenged the defendant's schedule asserting that the defendant failed to produce "raw data" to support Andrew's claim as to when Fukang actually started to strike the formwork.

115 In my view, reliance by the defendant on cll 1(a) and 3(a) of the Additional Terms for its submission is erroneous. Neither clause referred to 24 hours as the setting time for the concrete. Instead, they referred to the consultants' requirements which, according to Tan, was one day based on the guidelines in the Code.

116 The plaintiff, however, submitted that as the test cubes were still "green" after 24 hours, the defendant should have exercised more caution and not relied on the guidelines in the Code. The plaintiff's submission referred to Patterson-Kane's cross-examination wherein he agreed that there should be more caution if it was known that concrete was soft to the touch after 24 hours. The plaintiff further highlighted the opening words (italicised below) of sub-cl 6.2.5.3.2 at Part 1[27] of the Code which states:

Striking period of cast in situ concrete

In the absence of other information the recommended periods before striking formwork given in table 6.2 may be used for concrete made with ordinary or sulphate-resisting Portland cement.

Table 6.2 stipulated a setting time of one day for vertical formwork to columns, walls and large beams and three days for soffit formwork to slabs.

117 The plaintiff added that the defendant should instead have looked at alternative striking times set out in other guidelines. This was provided in the above sub-clause of the Code, which went on to say:

> Alternatively, striking times can be determined from tables published in CIRIA Report No. 136 "Formwork Striking Times – Criteria, Prediction and Method of Assessment. These take account of the cement type, the grade of concrete, the dimensions of the section, the type of formwork, the temperature of the concrete when placed and the mean air temperature.

CIRIA stands for Construction Industry Research and Information Association a British body and its Report No 136 was produced in court.[28] Wee had relied on the Report to support his written testimony that various matters ought to be considered to determine the striking time of formwork.

118 Although it was denied by Andrew, I believe Fukang more likely than not removed all the formwork from the first seven columns on 13 July 2002, for the reasons set out in [102] above. Similarly, despite Andrew's denials to the contrary, I am convinced that he did inform Ng on 16 July 202 that he/the defendant could not wait any longer and had struck all the formwork despite being told by Ng on 13 July 2002 not to de-mould the columns until after the plaintiff had conducted tests of the on-site test cubes. Ng no longer works for the plaintiff. There was no reason for him not to be truthful. This aspect of Ng's testimony was corroborated by Giam and Toh, who overheard his conversation with Andrew on 13 July 2002. Indeed, the defendant's fax of 15 July 2002 sent by Andrew to the plaintiff recorded Ng's advice to the defendant to allow a longer setting time for the formwork. Although Giam and Toh could not recollect certain events with accuracy, I do not think it was a deliberate act on their part to avoid answering questions in cross-examination; they spoke the truth.

119 I doubt that the defendant and/or Fukang checked the on-site test cubes as Chew claimed, before Fukang struck the formwork of column 5/B on 14 July 2002. I accept the submission of the plaintiff in this regard (at [103]). Chew, as the defendant's foreman, would be expected to support whatever Andrew said, which he did.

120 It would be appropriate at this juncture to give my assessment of the defendant's witnesses, particularly Andrew. It is noteworthy that Andrew generated voluminous correspondence on the defendant's behalf in relation to this dispute. He, not the plaintiff's representatives, prepared minutes of their meetings relating to the resolution of the defective concrete and/or columns. Ng had criticised the minutes Andrew prepared of the meeting on 17 July 2002 as inaccurate. It was obvious from the letters that Andrew wrote on the defendant's behalf, that he was eager to pin liability on and required admission of responsibility from the plaintiff for the cost and attendant delay, before he agreed to demolish the columns. His letters were at best self-serving and at worst did not reflect the true position. I am equally sceptical of the accuracy of the schedule that Andrew produced in court (see [114] above), purportedly showing the striking times (of Fukang) for the 14 columns. I disbelieve his claim that Toh and/or Giam were at the site on 15 and 16 July 2002, inspected the formwork and gave their approval before the defendant struck the formwork for seven columns. These

representatives of the plaintiff, especially Toh, were in no position, nor did they have the authority, to tell the defendant when to strike the formwork. Andrew, however, needed their presence and approval to pin liability on the plaintiff for the defendant's premature removal of the formwork and subsequent replacement of the affected columns.

121 There was only one letter from the plaintiff to the defendant that was of any significance, *viz* that dated 6 August 2002[29] written by its then general manager. Ng had disassociated himself from the letter which contents, *inter alia*, referred to slow setting of concrete being not an uncommon phenomenon, and cited other sites encountering the same problem on 12 and 13 July 2002. I disregarded the letter as the maker did not testify.

122 It was unreasonable of the defendant to require the plaintiff to obtain endorsement from a professional engineer that the last seven columns were structurally sound before the defendant would dispense with their demolition. No independent engineer would accept such an assignment, when he did not design the structures. That task fell on Tan, who was the superintending officer as well as the professional engineer engaged by the defendant for the project.

123 Before I make my finding on the six issues for determination (see [93] above), I need to address two items in the defendant's counterclaim which touches on liability. The defendant had claimed a delay of 44 days. Connors[30] had allocated 32 days for the delay in the construction due to the recasting of the 14 columns and the difference of 12 days to the change in the sequence of construction at the fifth storey slab.

124 The plaintiff submitted that it should not be blamed for the change in the sequence of construction. Although the defendant alleged that reconstruction of the columns necessitated the sequence of work being changed from areas A, B and C to B, C and A, this was not reflected in the "as-built" programme exhibited in Connors' affidavit. The plaintiff contended that the change of sequence was actually due to poor project planning by the defendant. The alleged lack of access by the crane to the fifth storey was not caused by obstruction from the columns while they were being reconstructed but by underground trench works.

125 In support of its stand, the plaintiff referred to the fact that the second to fifth storeys of the project had the same cantilever system between areas A and B. The formwork could not therefore be transported by sliding it from area A to B. Cranes had to be used instead. However, cranes could not be used to lift the formwork for columns of the second to fourth storeys because the ongoing underground trench works blocked access to area A. Testimony to this effect was adduced from Andrew. During construction of the first storey slab/floor, trench works had not started. Indeed, the "as-built" programme exhibited to Connors' affidavit showed that work in area A on the second storey had not started as at 23 September 2002, even after the columns of the third storey area A had been cast and part of area C works there had begun.

126 The plaintiff pointed out that the defendant gave no explanation why it departed from its own revised sequence of work. The plaintiff submitted that Andrew's poor planning (despite his denial) of carrying out underground trench works at the same time as structural works instead of completing the trench works first *before* casting the second storey slab, caused the delay of 12 days. On the evidence adduced from Andrew and Connors, I accept the plaintiff's submission.

The decision

127 On the issues set out in [93] above, I set out my findings below.

Issue (a): Did the slow setting of the concrete per se cause the cracks in the columns?

128 The slow setting of the concrete did not *per se* cause the cracks in the columns.

Issue (b): Who made the decision to strike the formwork from the columns?

129 It was the defendant (Andrew) who made the decision to strike the formwork.

Issue (c): Was the decision to strike the formwork reasonable?

130 Issue (c) has to be addressed separately in relation to the first seven and the last seven columns. Although Andrew's conduct in this regard was criticised by the plaintiff, I am prepared to accept the defendant's case that there was no reason for the defendant and its subcontractor, Fukang, not to strike the formwork for column 5/B on 14 July 2002, regardless of whether they checked the test cubes cast on 12 July 2002. This was because past deliveries of concrete from the plaintiff did not exhibit slow setting properties. There was no reason for the defendant or its subcontractor to suspect that the batch delivered on 12 July 2002 would not be normal in its characteristics.

131 As for the last seven columns, I am satisfied from the evidence adduced that the defendant's conduct was indeed unreasonable. Having been alerted to the slow setting problem of the concrete for the first seven columns, it was reckless of Andrew to disregard Ng's advice and strike the formwork without allowing for a longer setting time. The defendant could not rely on the 24 hours' setting time set out in the Code to excuse his conduct since there was a qualification to sub-cl 6.2.5.3.2 which I have referred to earlier (at [117] above). Given that the first floor slab cast with the same slow setting concrete did not show cracks or suffer structural defects, the remaining seven columns would not have needed to be demolished had Andrew listened to Ng.

Issue (d): Did the decision to strike the formwork cause the demolition of the 14 columns?

132 The answer to the question whether the decision to strike the formwork caused the demolition of the 14 columns is yes.

Issue (e): Were the consequential expenses and losses claimed by the defendant in the counterclaim a direct result of the decision to strike the formwork?

133 The rule on remoteness of damages was spelt out in *Hadley v Baxendale* (1854) 9 Exch 341 and interpreted and restated first, by the English Court of Appeal in *Victoria Laundry (Windsor) Ltd v Newman Industries Ltd* [1949] 2 KB 528 and subsequently, by the House of Lords in *Koufos v C Czarnikow Ltd (The Heron II)* [1969] 1 AC 350. The rule is to the effect that a party that is in breach of contract is liable for damages that may fairly and reasonably be considered to arise, either naturally according to the usual course of things from such breach, or, such as may reasonably be supposed to have been in the contemplation of both parties at the time they made the contract as being the probable result of the breach. It is common ground that the plaintiff agreed to pay for the cost of demolition and replacement of the first seven columns (for whatever reasons) including 5/B. Such cost would reasonably be contemplated by the parties to arise from the failure by the plaintiff to supply concrete of good and merchantable quality, under cl 3(a) of the Additional Terms. The plaintiff should accordingly bear the costs save for those relating to columns 2/B, 3/A and 4/B on which Wee testified (see [110] above) that there were no cracks.

134 As regards the last seven columns, however, their demolition and the consequential loss could

have been avoided had the defendant heeded the plaintiff's advice. I accept Wee's testimony that these columns were structurally sound, based on the Windsor probe tests carried out by the plaintiff on core samples.

135 There is no evidence that the defendant's critical path of construction was affected by the demolition and replacement of the first seven columns. Indeed, it would appear from Connors' evidence ([124] to [126] above) that the defendant only has itself to blame for the delay in completion, not the plaintiff. I will not comment on the alleged delay of 32 days due to the demolition and reconstruction of the columns generally, as that should be a matter for determination by the Registrar at the hearing of the assessment of damages. However, it appears to me on a balance of probabilities, that the defendant had failed to discharge the burden to prove that its sequence of construction was disrupted by the demolition and reconstruction of the first seven columns. Accordingly, its claim for 12 days' delay resulting therefrom is disallowed. The defendant cannot claim for any delay resulting from the delay in demolishing the last seven columns, in view of my finding in [132] above. The plaintiff's request to the defendant to demolish the last seven columns on 2 August 2002 must be seen in the light of Ng's explanation in [70] above, which cannot be construed as an admission of liability.

136 The doctrine of *res ipsa loquitur* has no application to this case; the plea is misconceived.

Conclusion

137 Accordingly, there will be judgment for the plaintiff on its claim for $247,856.34 with interest at 6% per annum from the date of the writ to the date of judgment.

138 There will be interlocutory judgment for the defendant on the counterclaim with damages to be assessed, subject to the qualifications set out in [133] to [135] above. Costs of the assessment will be reserved to the Registrar.

139 The issue of costs on the claim and counterclaim can only be dealt with after damages on the counterclaim have been assessed by the Registrar. Accordingly, I grant the parties liberty to apply on the issue of costs.

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[1]DW1.

[2]DW2.

[3]See AB718.

[4]In para 16 of his affidavit.

[5]DW3.

[6]DW4.

[7]DW5.

[8]PW1.

[9]PW2.

[10]PW3.

[11]In item 4.

[12]At AB160.

[13]As recorded in items 4 and 7 of the minutes.

[14]See AB206-207.

[15]PW4.

[16]Paras 8 and 12 of the Defence and Counterclaim.

[17]PW1.

[18]PW2.

[19]At para 51 p 46.

[20]DW5.

[21]At para 34 p 30.

[22]Para 35 p 31.

[23]See AB97.

[24]At AB1415.

[25]In para 101 of their submissions.

[26]At AB700.

[27]See AB656.

[28]As exhibit P1.

[29]At AB200.

[30]DW4.