Ove Arup v Mirant Asia-Pacific Construction Ltd [2005] ABC.L.R. 12/21

CA on appeal from TCC (HH Judge Toulmin CMG, QC) before Mummery LJ; May LJ; Richards LJ. 21st December 2005

LORD JUSTICE MAY:

Introduction

1. The first claimant, Mirant Asia-Pacific Construction (Hong Kong) Limited, is a company which designs, constructs and commissions coal fired power stations. Mirant was formerly known as CEPA Slipform Power System Limited ("CEPAS"). The second claimant, Sual Construction Corporation, is a subsidiary of Mirant incorporated in the Philippines in order to undertake the design, construction and commissioning of a power station at Sual in the Philippines.

2. The first defendant, Ove Arup & Partners International Limited ("OAPIL"), are international engineering consultants. The second defendant, Ove Arup and Partners Hong Kong Limited ("OAPHK"), are engineering consultants practising principally in the Far East.

3. The claimants claim against the defendants damages for breach of contract in relation to the construction of the power station at Sual. The claims arise out of the failure in about April 1997 of two of the main foundations of Boiler House No. 1. The two foundations were designated as G2 and G5. G2 settled by 46mm: G5 by 66mm. They did so very early in the process of constructing the superstructure when the load was a very small fraction of the eventual design load. There was no equivalent problem with Boiler House No. 2, nor, so I understand, with the very many other foundations throughout the site.

4. The claimants claim damages against the defendants for breach of one or both of two contracts. By a judgment of 11th June 2003, His Honour Judge Toulmin CMG, QC, sitting in the Technology and Construction Court, decided five preliminary issues as to the making and construction of these contracts. The principal issue then was whether both or either of the agreements incorporated the terms of the 1991 FIDIC Client/Consultant Model Services Agreement including a five year limitation of liability period and a limit of compensation of £4m.

5. There was an appeal to this court against some of the judge's decisions on the preliminary issues. This court decided the appeal in judgments delivered on 2nd December 2003, [2003] EWCA Civ 1729. As a result of the appeal, it has been determined that there was:

   a) a design agreement made on 29th May 1995 between CEPAS and OAPIL and OAPHK on the terms of a letter of intent of that date as pleaded in paragraph 23 of the particulars of claim. This agreement did not incorporate the FIDIC terms.

   b) a ground investigation agreement made on the terms of a written proposal dated 8th March 1996, which Mr Elliott, then Managing Director of CEPAS, signed on 15th or 16th March 1996. This agreement did incorporate the FIDIC terms.

   It was thus in the claimants' interest to establish that the defendants were in breach of the design agreement; and in the defendants' interest to show that they were, if at all, in breach of the ground investigation agreement.

6. I shall refer to the claimants as "Mirant" and to the defendants as "Arup", unless greater precision is necessary.

7. The judge heard the main liability issue over 18 or so days between 17th November 2003 and 22nd January 2004. Sixteen of these days were before Christmas 2003, after which the parties had about a month in which to prepare written submissions. There were then 2 days for oral closing submissions in January 2004. The judge delivered a written judgment on 21st July 2004. His order is dated 2nd August 2004. So far as remains relevant to this appeal, he decided that Arup were in breach of the design agreement by failing to design the Unit 1 boiler foundations with due care and skill, and by failing to verify the design assumption upon which the design was based; but that they were not in breach of the ground investigation agreement relating to an inspection and approval of the G5 foundation nor in failing to inspect and approve the G2 foundation. He further decided (a) that the formation levels of the foundations were not lowered after an inspection by Arup on 23rd July 1996; and (b) that the settlement was caused in the manner set out in the evidence of Professor Hudson and in particular by a collapse in the structure of the rock.

8. Arup appeal against these decisions by permission of Potter and Longmore LJJ. Longmore LJ had initially refused permission on the papers. There is a half-hearted cross-appeal by Mirant, with permission of Longmore LJ, against the finding that Arup were not in breach of the ground investigation agreement. The cross-appeal is academic, if the appeal fails.

9. The judge's most critical decision was that the two foundations which failed were founded on undisturbed in situ ground. A lynch pin of Arup's appeal is that this finding was, on a proper evaluation of the evidence, wrong. It is a finding of fact in a complicated technical case by a specialist judge of the Technology and Construction Court. The approach of this court to appeals having these characteristics was considered in some depth in ***Yorkshire Water Services v Taylor Woodrow Construction*** [2005] EWCA Civ. 894. I refer to paragraphs 19 to 32 of the main judgment in that appeal. Relevant highlights are in paragraph 27: *"The burden on a prospective appellant in these areas is nevertheless hard to discharge. In my view, the more complicated and technical the facts, the harder generally speaking is the burden. The reason again is obvious. The more complicated and technical the facts, the longer and more expensive would be this court's enquiry, whether by review or rehearing, and the more disproportionate would be the whole exercise for the parties and the court alike. Importantly, this court would have the disadvantage of not having heard any of the witnesses, including the experts, give oral evidence. I venture to think that, at the extreme,*

some questions of fact may be so complicated and technical that they should only be investigated in detail judicially once, provided that the resulting decision is not palpably incompetent."

And in paragraph 32, quoting from paragraph 141 of the main judgment in **Thomson v Christie's** [2005] EWCA Civ. 555: *"The judge's factual conclusion … was a composite amalgam of a large number of particular judgments where an assessment of the weight and persuasiveness of each of the experts as witnesses was of critical importance. … it would, I think, be a travesty of the appellate process to interfere with the judge's composite judgment here … unless it were shown that he made one or more glaring and important misjudgments."*

10. The present case is broadly comparable with *Yorkshire Water* and *Thomson*. Of the three, *Yorkshire Water* was perhaps the most impenetrable, but comparisons of this kind are otiose. Arup have a distinctly uphill task to persuade us that the judge's critical findings of fact were wrong. Their other main ground of appeal is that the design agreement did not oblige them to verify the design assumption for the foundations.

The design agreement

11. The development of Arup's proposals for the design work began in 1994. In April 1995, they produced revised proposals. There were discussions in April and May 1995 culminating in a formal letter dated 23rd May 1995. A version of this letter was signed by Mr Elliott on behalf of CEPAS and Mr Higson on behalf of Arup on 29th May 1995 and was referred to as a letter of intent. This document comprised the design agreement.

12. Arup were to carry out a "Concept Design" in Hong Kong. They were then to undertake preliminary and detailed design from a project office in Putney. Each of these were to be undertaken in accordance with Revision C of Arup's proposal. The preliminary and detailed design included the boiler foundations. Each package was to include general arrangement drawings and details for tender and for construction, and also calculations justifying the design.

13. The revised proposal had also included Technical Site Supervision Services, but these were omitted from the letter of intent, which stated that:

"The provision of technical site supervision and quality control by Arup/CEPA Slipform shall be based on the formation of a joint team. The detailed arrangements and associated fee are to be the subject of discussion and agreement at a later stage."

The proposal had offered to provide a small team of engineers on site whose roll was to include:

"… confirm that the design intent is being fulfilled."; and

"The team will cover approval of foundations for construction."

It was further said that*: "During site construction the Site Team will determine whether the design intent is being fulfilled and inform the Slipform Construction Manager of any work which is not fit for purpose together with proposals and plans to remedy the situation."*

14. Arup employed a number of highly qualified geologists who worked together more like a college of professionals than simply a group of employees. The head of the team was Dr Littlechild who was based in Hong Kong. Dr Redding was a principal geologist who then worked in Arup's London office. Others included Mr Pascall, Mr Manning and Mr Bowden. Dr Redding and Mr Pascall were of similar established seniority.

15. The judge defined his understanding of Arup's relevant duty under the design agreement in paragraph 38 of his judgment as follows: *"As I understand it, the duty under the design agreement is to carry out the design. In order to achieve this, it may be necessary to have further information about the ground conditions. If this is the case, the designer will advise the client that more information is to be obtained. The client may enter into a separate agreement with the designer to provide or supervise the further investigations or instruct a third party to carry out the task. There is a clear distinction between the separate ground investigation and the verification of the design assumptions, which is an integral part of the designer's duty. The ground investigation itself is not within the normal contractual requirements of the original design contract."*

Arup challenge parts of this definition of their design duty under this design agreement.

The design assumption

16. The site for the power station was a seaside promontory, from which some 20m of ground had to be removed by blasting and excavations. The relevant eventual ground level around the boiler house was thus well below the original ground level. G2 and G5 were two of the principal foundations of the Unit 1 Boiler House. They were to be cast in situ reinforced mass concrete foundations, rectangular in plan, and 5m. x 3.6m. and 1.5m. deep. They were among the highest loaded foundations in the plant. Their construction required excavating to formation level, blinding the formation level, placing of holding down bolts, reinforcing bars and formwork, and the pouring of the concrete.

17. There were at least two geological faults in the vicinity of the two boiler houses. One was to the west of the Unit 1 Boiler House, running in a north-west/south-east direction. The other fault ran in an east-west direction close to and under the Unit 1 Boiler House. Mirant say that this fault is in the vicinity of the foundations G2 and G5. It was identified by Dr Redding when he visited the site in September 1995 and was known as "the Redding fault".

18. Arup's design of foundations which included G2 and G5 was based on an assumption that the relevant ground had a bearing capacity of 3MPa. This was an assumption only, depending on site and geological information which Dr Redding and others regarded as incomplete.

19. An account of the process by which this assumed bearing capacity evolved and of the information progressively available to Arup may be found in paragraphs 62 to 141 of the judge's judgment for the period between April 1995 and February 1996. This bears detailed consideration, but I give highlights only, since the eventual position is scarcely controversial.

20. A variety of information about the ground conditions was or became available to Arup. Detailed ground investigation in the area of Boiler Unit 1 could not be carried out immediately because it was sited beneath the hill that was to be removed. At a meeting on 12th July 1995, Dr Littlechild expressed the view that the bearing capacity was between 3MPa for shallow rock and 10MPa for slightly fractured rock. Dr Oldroyd expected that, after the hill had been removed, strong rock would be found at formation level for the boiler house.

21. In a document dated 11th August 1995, Arup envisaged that there would be a detailed site investigation reviewing all the geological information and calculations to assess the bearing capacity of the relevant ground. Dr Redding wrote a comprehensive report dated 17th August 1995. He warned that "the variable and often low strength of the rock, even at considerable depth, may cause foundation problems for heavily loaded structures". The judge summarised Dr Redding's recommendations in paragraph 88 of the judgment as follows: *"Put shortly, Dr Redding was recommending a ground investigation by accurate and detailed mapping as his preferred way forward. He amplified his views in oral evidence. He envisaged recording on a map the variations in rock strength in the area in question, marking the orientation and dip of the discontinuities, and the nature and extent of weathering or alteration of the rock. The rock strength would be assessed by a point load machine."*

22. Dr Redding was nominated as Arup's main geological advisor. He visited the site for a week in September 1995. He identified the Redding fault under or adjacent to G2 and G5. His impression was that the rock was moderately to highly weathered and moderately closely to very closely fractured.

23. Arup developed a ground investigation proposal, whose final version was dated 21st December 1995. It recommended, among other things, geological mapping, bore holes, trial pits and probe holes under the full time supervision of an experienced full time geologist. In the event, no additional bore holes were undertaken. The nearest existing bore hole to the site of the boiler house foundations was 100m from G2 and even further from G5. None of the probe holes was at the site of the Unit 1 Boiler House. There was to be a single trial pit near G2, but it was not in the event excavated in that position.

24. In a letter dated 20th December 1995, a Mr Talbot, who was about to leave Arup, emphasised that a projection of ground conditions from existing bore holes was uncertain and could only be a generalised interpretation. The letter concluded that an appropriate maximum bearing capacity would be 0.8MPa. This was later amended by Dr Redding to 3MPa, when he issued a new version of the letter on 4th January 1996. The last paragraph then stated that, taking all the known ground condition factors into account, an appropriate maximum allowable bearing value for all footings would be 3MPa. The effect of this change was that the dimensions of the foundations were three to four times smaller than they would have been for a bearing capacity of 0.8MPa.

25. The judge said in paragraphs 127-9 of the judgment:

"There is no allegation that Dr Redding's revised estimate was negligent. In my view it was not negligent but it had to be understood in the context that it was a preliminary assumption which was to be subject to a detailed process of verification. It was important to emphasise, as Dr Redding did in both the original and revised memorandum, and again in oral evidence, that the estimate was intended to enable the design to be progressed in its preliminary form.

Dr Redding said clearly in oral evidence that he had been surprised to discover that his preliminary design assumptions were used for the final design. I accept his evidence. His was intended to be a working assumption which would need to be verified before work on the final design was complete. The verification process could have been expected to provide the design team in London with an assessment either confirming the design assumption or indicating the changed assumption that the designers would need to take into account. In his oral evidence Dr Endicott [one of Arup's expert witnesses] agreed that a degree of reassessment was required as the design went on.

Dr Oldroyd in London did not wait for any confirmation of the crucial assumption as to the maximum load bearing stress before starting the detailed design of the boiler unit."

26. The judge then said in paragraph 133: *"There was already a gap in Arup's chain. Dr Redding made what he intended to be a highly provisional assessment which had been implemented by the design team as a firm assessment. Dr Oldroyd's witness statement (para 41) made it clear that it was for the Geotechnical team to undertake particular studies. He would wait until they responded with the relevant information and until he received further information he would proceed on the basis of the existing assumption."*

27. On 6th February 1996, Dr Oldroyd prepared a draft of the Boiler and Milling House Design Basis, which was passed to CEPAS. This stated that the Boiler House had an assumed safe bearing capacity of 3MPa. Further ground investigation work was intended to confirm this value at an early stage of the design and to establish that the foundations would be founded on consistent material. The judge said at paragraph 137: *"Dr Oldroyd explained in his statement that he understood that it was intended that Dr Redding's assessment should be confirmed by further ground investigation work. He said that there was also to be surface mapping and visual inspection by the Arup geologist on the site who was supervising the ground investigation. It is apparent that Arup agreed to proceed with the detailed design leaving the load bearing assumption (which Dr Littlechild thought was conservative) to be verified later."*

28. In January 1996, Arup were expecting to be involved on site in two separate capacities. They were expecting to supervise the ground investigations. They also expected that the person supervising the ground investigations would also be involved in surface mapping and visual inspection to verify important assumptions relating to the geology including the bearing capacity for the boiler house foundations of 3MPa.

29. On 4th February 1996, NSBC, who were employed by SCC as contractors, were instructed to proceed with the ground investigation work which Arup had specified. In the event, the ground investigation which they carried out scarcely added to Arup's knowledge of the ground conditions relevant to G2 and G5.

The ground investigation agreement

30. The ground investigation agreement was made when, on 15th or 16th March 1996, Mr Elliott wrote and initialled the word "O.K." on a proposal which Arup had revised on 8th March 1996. It provided for "the ground investigation work described in this document". This comprised the supervision of geotechnical and geophysical investigations, including "a bore hole, probe and trial pit ground investigation of the whole site". For this, Arup were to provide one full time geotechnical engineer to supervise the bore hole, trial pit and probe hole investigation. As well as supervising the ground investigation work, "he would be able to fulfil the requirements of a site foundation engineer in such matters as approving ground conditions for foundations". It is agreed that the terms of this agreement were subsequently varied so that Arup were only required to inspect and approve foundation formations upon request.

Mr Manning on site

31. In late March or early April 1996, Dr Redding, with the help of Mr Manning, prepared a comprehensive briefing note. This included reference to the assumption that the ground had a load bearing capacity of 3MPa. It was made clear that the ground conditions were uncertain and variable. The briefing stated that information from the ground investigation work was critical to the foundation design for various components of the power station. It emphasised that the rock quality was variable due to faulting, fracturing, deep weathering and alteration. Rock quality at formation level would be important since much of the rock would now be exposed. Rock quality could best be assessed by visual inspection combined with shallow pit probing. Data from bore holes and probe holes and from laboratory tests would be used for ongoing design work. Arup supervisors were to undertake mapping and recording of ground conditions in foundation pits and trenches in addition to supervising bore holes and probe holes.

32. Mr Manning, suitably briefed and in possession of the briefing pack, was on site between 13th April and 28th June 1996. As the judge said at paragraph 152 of his judgment with reference to the briefing pack: "*It follows from this that Mr Manning and Arup knew that the existing information on ground conditions was unreliable and needed to be subjected to a detailed and careful verification process, the results of which were communicated to the design team. They also knew that there was a particular concern* that the quality of rock was variable under the main power plant including the boiler house."

33. Mr Manning was well qualified with an expertise in mapping by aerial photography. He took many photographs. He supervised NSBC's work, which was nevertheless very slow. No doubt he did what he did competently, but it was not suggested to us that anything he did made any significant contribution to verifying the assumption that 3MPa was a safe and appropriate bearing capacity for G2 and G5. He did not do any mapping in the plant area. He said in evidence that most of the exposures were covered by a thin layer of gravel, so mapping was not feasible.

34. Arup had specified a trial pit near G2. It was in the event moved some 30m away and there was no ground investigation work under or immediately adjacent to Boiler Unit 1. The log for this trial pit indicated fractured or very closely fractured rock which was reasonably easy to excavate. Dr Hencher, one of the experts, considered that this called for reconsideration of the foundation design assumption. Dr Endicott disagreed.

35. G2 and G5 had been excavated to formation level by 23rd May 1996. But they were to the wrong orientation and depth and had to be removed and reconstructed. On 28th May 1996, Mr Manning wrote a report in which he stated that in a number of areas, including the boiler house, formations had been blinded without approval of the formations. On 11th June 1996, when Mr Higson visited the site, there were concerns about lack of comprehensive and effective quality assurance procedures. There was no engineer from CEPAS or Arup charged with approving formations. Mr Manning's role was to monitor and record the ground investigation, but he would advise where possible on rock formations.

36. An Arup note of a meeting in Hong Kong on 19th June 1996 recorded that the detailed design of the Unit 1 boiler foundations would need to be reviewed when an assessment of the rock formation integrity was possible. As the judge said, there was "no reference to any specific requirement on Mr Manning to verify the assumptions that had been made for the design of the foundations of the boiler house."

37. The judge recorded that the project lacked direction and that NSBC's work was subject to serious criticism. "Arup's role, as it was understood by the participants, related to supervision of the ground investigation and approval of the formations."

38. After he left the site, Mr Manning completed a Bedrock Profile Plan on 18th July 1996 showing the location of grade III rock or better. This did not provide any information about the nature of the ground in the area of the boiler house. In the absence of documents, the judge concluded on the balance of probability that Mr Manning did not carry out any more detailed mapping than was disclosed in the documents before him. If the mapping

exercise had been given the importance envisaged by Dr Redding, an appropriate mapping plan showing the ground at and surrounding Boiler House 1 would have been retained in Arup's office with an assessment of whether any design change was needed.

Mr Pascall on site

39. Mr Manning was succeeded on site by Mr Pascall, a very senior Arup geologist. He was to arrive on site in early July and remain until 6th August 1996, by which time the ground investigation was expected to be complete. He saw his task as replacing Mr Manning. Mr Pascall was not briefed as Mr Manning had been. He was not specifically asked to verify Dr Redding's design assumption, nor was he aware that he was expected to do this. Indeed it was becoming rather late in the day to do so. He did not even know that the assumed design bearing capacity was 3MPa, until he telephoned Hong Kong on 23rd July 1996 when he was looking at the formation for G5.

40. On 16th July 1996, Mr Eller of CEPAS endorsed Arup's drawing for the Boiler Unit 1 foundation plan with the words:

"5 Bases to be founded on un-fractured rock. All formations to be approved by CEPAS and where necessary brought to level and consolidated using mass concrete as directed by CEPAS."

41. Mr Pascall had a look at the formations for G5 and G2 on 23rd July 1996. The judge said of this in paragraph 194 of his judgment: *"It was essentially different in character to the task which Dr Redding had expected to be undertaken before the detailed design stage (or at the latest in the verification of the completed detailed design). It was not based on detailed geological mapping required to verify a preliminary design assumption."*

42. The judge considered exactly what Mr Pascall did do that day. There were no detailed contemporaneous records other than a relatively uninformative daily site record whose terms the judge records in paragraph 197 of his judgment. Mr Pascall was first asked to remember what he did on 23rd July some 9 months later, when, on 1st May 1997, Mr Nyambayo sent him a fax saying that there was a problem with one of the main foundations and asking for his recollection. Mr Pascall replied by fax on the same day without consulting any records. He said that Arup had not approved any concrete when he was on site. He said that the rock at G5 was weaker than that in the footings to the north, but was assessed by hitting with a hammer to be Grade III. He said that there was material on the footprint, so he stopped work and made them clean up the base. He said that after the site formation, only hard outcrops of basalt could be seen in the formation.

43. The judge gave an account of Mr Pascall's evidence in his witness statement and given orally in paragraphs 207-216 of the judgment. In brief, Mr Pascall made a visual inspection of the G5 formation. He checked the quality of the rock using a geological hammer. This showed the rock to be variable, Grade III over most of the area, but Grade IV/V to the north east and south west. He said that he judged the rock to be adequate to sustain a bearing pressure of 3MPa. He stepped down at most 300 to 400mm into the foundation excavation. He did not know that there may have been a geological fault running beneath the boiler house. He thought this unlikely. The judge said of this inspection at paragraphs 212-213 of the judgment:

"None of this evidence is consistent with Mr Pascall undertaking a detailed verification whether by mapping or otherwise to confirm or modify Dr Redding's preliminary design assumptions.

… I am satisfied that the exercise which he was undertaking was a form of verification that the ground would sustain the bearing pressures that he had been given by Dr Oldroyd on the basis that the geological team had already reached a firm assessment. It was clearly not the type of systematic verification contemplated by Dr Redding in January 1996. It amounted to using a hammer and taking a view on the basis of his great experience, but it was not a detailed examination."

44. The judge was not prepared to accept that, in the absence of contemporaneous records, Mr Pascall remembered that the excavation was only to a depth of 300 to 400mm.

45. Mr Pascall also looked at G2, but it is not suggested that he inspected it in the way that he had inspected G5. The judge then said in paragraph 217 of the judgment: *"I find that Mr Pascall is an excellent geologist who found himself, rather against his will, in Sual with a very ill defined role which did not include a specific task of verifying the load bearing capacities of the rock in the boiler area. If he had by chance found evidence in the course of his cursory examination, which was inconsistent with the bearing capacities which he had been given by Dr Oldroyd, he would no doubt have recorded it in the site report, or raised the problem in a document which would have been retained and to which my attention would have been drawn. Clearly, whatever he did, it did not put him on enquiry that Arup was taking a serious risk in designing the boiler house on this site. Short of this he would not have any incentive to flag up problems to the design team in London (or to his superiors) at a time when Arup had already completed the detailed design and he had not been given the specific task of verifying the design assumptions."*

The judge was not prepared to make other positive findings on the basis of a recollection many years later of events which Mr Pascall had no cause to remember until over 9 months after they had happened.

46. On the following day, 24th July 1996, there was a typhoon, which caused extensive flooding. All open formations had to be pumped out. It is not now suggested that the typhoon or its consequences are material to the issues in this case.

Events after Mr Pascall left site

47. The records available to the court for the period which followed were exiguous. There is a record of blinding to G2 and G5 from 9th August 1996. Other parts of the site continued to be excavated by blasting. Reinforcing bars were being fixed for Boiler Unit 1 between 12th and 27th August and specifically on 19th August 1996. A photograph shows reinforcing cages in one of these foundations on 27th August 1996. The reinforcement had not been fixed in the correct sequence and had to be dismantled on about 2nd September to fix holding down bolts. These were installed between 10th and 24th September. On 4th September, there was excavation at F8 foundations (which G2 and G5 were) for working space and stub settings. These were blinded on 9th September using 2.57 cubic meters of concrete. The contractors were claiming payment for excessive thicknesses of blinding concrete. On 23rd September, the setting out of Boiler 1 anchor bolts for F8 bases was progressing. This was confirmed by a photograph. The notes of a weekly meeting in early October 1996 said that an inspection of F8 bolts was delayed until all blasting operations in the area of the boiler unit were complete. There was fabrication and installation of the structural framework on 18th and 19th October. Blasting in the power block area was still going on on 23rd October. A record to 31st October showed a control volume of blasting for F8 of 1.80 cubic meters against an actual site measurement of 19.28 cubic meters. The difference was explained by Mr Smith, CEPAS' site manager, as resulting from fragmentation of the rock during blasting operations. Between 1st November and mid-December, discrepancies in the levels of holding down bolts and formwork were discovered and corrected. The structural concrete for G2 and G5 was poured on about 23rd January 1997. The foundations were handed over for steel erection on 2nd April 1997. Movement at G2 and G5 was first noticed on 13th April 1997.

48. An exploratory investigation around the foundations was undertaken on 28th April 1997. This reported evidence of loose and fractured rock.

49. On 15th May 1997, Mr Hawkins, a chartered geologist and chartered engineer, was instructed to carry out an independent analysis. His initial conclusion was that the ground was behaving neither like a sound rock nor a fractured rock. It was essential that the nature of the ground below the foundations was known. He anticipated that the foundation rested on very weak materials. A Mr Daudigny wrote on 23rd May 1997 that both G2 and G5 foundations were bearing on a weak soil that was not hard basaltic rock nor weathered fractured rock. Various investigations took place including importantly trial pits beside the foundations and, once the blinding was removed, mapping of the exposed surface. On 12th June 1997, Mr Hawkins inspected a trial pit on the east side of G2. It extended about 150mm below the level of the blinding. At the base of the pit was a small amount of strong jointed rock, but the ground was generally very weak, with highly decomposed basaltic rock which he was able to excavate with his fingers. He excavated to 750mm below the base of the blinding using a spade. The ground was soft enough to be excavated to an even greater depth using a spade only. His preliminary conclusions on 14th June 1997 were that the most likely reason for the settlement was that the foundations rested on shattered and completely weathered material located on a geological fault. He noted from the investigation of G2 that drilling from the underside of the foundation to a depth of 1m took only 10 minutes. He noted other evidence of very weak friable materials.

50. Mr Hawkins considered in his report that the reasons for settlement were most likely to be one or more of the following possibilities:

    a) The foundations rested on naturally shattered and completely weathered material located on a geological fault.

    b) The rock below the foundations had been shattered, lifted and left in a loose state by blastings.

    c) The foundation rested on backfill to an excavation (i.e. on compressible made ground).

    In his witness statement, he thought that for G2 the weathered material was the most likely cause and in any event a substantial cause of the settlement. He had seen no evidence of rock backfill which could have produced the amount of settlement at G2 and G5. He thought that blast damage could have been a major contributory factor if it had occurred. But he felt that, given the appearance of the rock in the trial pit next to G2 which could have been excavated by hand, he would have been very surprised to see any blasting in these areas following completion of the site formation works, because the rock was not strong enough to require blasting. On the incomplete information before him, he thought that the cause of the movement had to be a combination of weathered material and blasting.

51. In early September 1997, Mr Nyambayo recovered a detonator cord at a depth of 1m below the blinding level of the pad footing. He noted that the top 300mm in contact with the blinding appeared to be made ground with a variety of rubbish embedded in it. In addition, explosive was found under G5 and east of G2.

52. Arup, meanwhile, considered the causes of the settlements and eventually published a report on 29th December 1997. The judge noted various Arup exchanges leading up to the report, suggesting that it was written with an eye to their own position. The conclusion of the report included:

    "Formations for the original G2 and G5 footings comprised fresh/moderately to completely decomposed Grade III/IV rock with open fractures caused by blast damage. The highly weathered and blast damaged rock was the primary cause of the settlement of the pad foundation."

    The judge said that the factual cause of the damage remains somewhat difficult to discern from the Arup report. He then said at paragraphs 327-9 of his judgment:

"The very process of investigation has made the task of reaching conclusions on the cause of the damage a more complicated one. Mr Bowden said in re-examination that because Arup had used rock breakers to break the ground around the foundations it was difficult to tell later whether the damage was caused by blasting or by the rock breakers. Mr Higson agreed in cross-examination that it was difficult to tell whether or not there was damage caused by blasting.

Arup's expert, Dr Endicott, had to concede in cross-examination that there was no evidence of blast damage at G2 and none on three sides of G5 although there was some evidence of cracks and open joints at a trial pit on the fourth side. Even here he qualified his answer by saying that it might be a local feature, although the associated question of the presence of loose debris required further analysis.

Arup's case in the end is that it is extremely difficult to reach a conclusion as to the failure of G2 and G5 but because the contractors have (they say) a proven record of incompetence, the cause must be blasting. They say that the conditions had changed dramatically from those found by Mr Pascall and that this must have been caused by the incompetence of the contractors."

53. In these proceedings, Mirant adopt in paragraph 58.8 of their Particulars of Claim factual findings from the Arup report as constituting the actual ground conditions beneath G2 and G5.

54. The judge reviewed the expert evidence. In paragraphs 330-346 he gave his impression of each of the experts as witnesses.

Breach of duty – the judge's decision

55. The judge considered together the issues (a) whether Arup exercised due care and skill in the design of Unit 1 boiler foundations and the verification of the assumption on which the design was based; and (b) whether they exercised due care and skill in the specification and supervision of the 1996 ground investigation. As to the design agreement the principal allegation was that Arup failed to take any adequate steps to satisfy themselves that the design assumption was properly verified or confirmed.

56. Arup's case was (or included) that it is good engineering practice to proceed with foundations on the basis of assumed allowable bearing pressures and to verify the assumption by the inspection of the foundations on site. That is what Mr Pascall did when he inspected and approved the G5 formation in July 1996.

57. The judge said that Arup were under an obligation to exercise due care and skill in designing the structures on ground that could bear their weight without movement above the permitted maximum set out in the contract. In order to discharge this obligation, Arup had to be satisfied that the design could be achieved on the basis of investigations carried out by it and by others. This required a verification process to confirm the preliminary design assumptions. Dr Redding was consistent in his opinion that further investigations were needed, aimed at defining better those rock characteristics which had a direct bearing on the particular construction. It was clear from the history of events from May 1995 to March 1996 and beyond that the verification process should have been systematic and detailed. Dr Redding's original ground investigation proposals included bore holes to confirm the foundations. The amended proposal included that there should be 5 trial pits and 2 probe holes in the area of the power plant other than the chimney area. This would have provided a means of verification of the design assumption, since the results would no doubt have been analysed in the context of the quality of the ground, both on the surface and at depth.

58. It was expected that, in addition to supervising the ground investigation, Arup would be involved in surface mapping to verify the important design assumptions. The judge found that it should have been a much more systematic and detailed exercise than that undertaken by Mr Manning. Dr Redding gave an acceptable explanation for adopting 3MPa, but it was a highly qualified preliminary assumption for a preliminary design. The judge accepted Dr Redding's evidence that he expected the assumption to be verified before the detailed design was finalised. Arup were not negligent in failing to prescribe bore holes. The judge accepted Dr Endicott's opinion that verification should be by inspection and detailed mapping. Dr Oldroyd expected the assumptions to be verified. Mr Manning did not carry out the detailed geological assessment which was required by Dr Redding.

59. The judge then said at paragraphs 455-6:

"What Mr Pascall was undertaking was a rough and ready exercise confirming generally that the basis for the design was correct. It was far removed from the detailed systematic mapping which Dr Redding had envisaged and which became particularly important in view of the qualifications on the estimate of 3MPa which Dr Redding had made. The record which Mr Pascall made of his visit and his inspection on 23rd July was cursory and reflected (as he thought) the unimportant nature of the task and his attitude to it. This was also reflected in the fact that he did not present any report to the design team and threw away any notes made on site presumably because he thought that they were of no importance.

I conclude that Mr Pascall was not attempting to and did not fulfil Arup's obligation to verify its provisional estimate of a bearing capacity of 3MPa in the course of his inspection. In this, he was not personally acting negligently. The task of verification which in the circumstances of this case required detailed and systematic mapping was never undertaken by Arup. In this regard Arup was negligent."

60. The judge was satisfied that Mr Pascall did carry out a form of inspection of the foundations of G2 and G5 on the afternoon of 23rd July 1996. The judge preferred the evidence of Dr Hencher to that of Dr Endicott that the process undertaken by Mr Pascall on 23rd July 1996 did not constitute verification of Dr Redding's design assumptions. It fell far short of what was required. The judge therefore concluded that in relation to the obligation

to verify the design, Arup failed to exercise due care and skill in verifying the design assumptions in relation to the load bearing capacity of the ground at G2 and G5. It seemed to the judge on the balance of probabilities that, if the detailed verification process had been carried out, the variability of the ground under the boiler unit would have been identified and analysed. He was satisfied on the balance of probabilities that the subsequent loss and damage would have been avoided.

61. The judge was not persuaded that Arup were in breach of the ground investigation agreement in failing to exercise due care and skill in the inspection or approval of the formation of G5 prior to blinding or in the inspection of the formation of G2. Mr Pascall was not personally negligent.

Causation

62. Arup's other main defence was that, even if they were in breach of one or other of the two agreements, their breach did not cause the loss. The main plank of this defence was that the ground conditions revealed in 1997 beneath the G2 and G5 foundations after they failed were not those which Mr Pascall had inspected on 23rd July 1996. It was to be deduced or inferred that the contractor had carried out further excavation to the formations after the 23rd July, and that the material on which these foundations were founded was not undisturbed in situ ground, but uncompacted fill and/or rock which had been damaged by blasting. This case was broadly inconsistent with the findings of Arup's own December 1997 report, which had been based on examination of the trial pits and the results of one or more bore holes. Nor was there any direct evidence of further excavation of the formations after July 1996. Arup also relied on further causes which the judge listed in paragraph 473 of his judgment. These were essentially alleged failures by CEPAS, SCC or NSBC to supervise or carry out the works properly.

63. Mirant's case was that the settlements of the G2 and G5 foundations were caused by the poor ground beneath them. This ground was in situ ground which had not been weakened by blasting nor infilling between July 1996 and April 1997. The case that it was in situ ground raised the question how settlements of the magnitude which occurred could have resulted from such very small loadings. Professor Hudson's explanation was that there had been a collapse in the structure of the rock. There was good rock, but also zones of very weak ground. In his oral evidence, he explained this by drawing a sketch, which showed zones of weak ground running diagonally downwards and intersecting beneath the foundations. The nature of the ground which he described was technically referred to as DIANE, which the judge had described and contrasted with CHILE material in paragraphs 46 and 47 of his judgment.

64. The judge described Arup's case in paragraphs 475-6 as follows:

"Arup's case is predicated on the premise that the settlements were large and occurred at an extraordinary low load which cannot be explained by the known and observed geology on the site. Secondly, they say that the condition of the G2 and G5 formations in 1997 was very different from those that Mr Pascall had observed in July 1996. They go on to say that their theory is made the more plausible by the poor performance of the contractors on site and is supported by the fact that the thickness of the blinding measured in August 1996 did not correspond with the thickness of the blinding measured in 1997. Thus it must be inferred, so they say, that the formations were altered by the contractor after July 1996.

Arup also say that Mr Brice's witness statement (albeit contradicted in his later evidence) indicated that G5 was altered after the time of Mr Pascall's inspection, that the contractor's records show further excavation after the 23rd July 1996, and that whereas Mr Pascall said that he did not see loose, blasted rock or fill left in situ, there are strong indications that the formation suffered from such defects at the time when they were examined in 1997"

65. Arup argued their factual case in this appeal under the following heads:

(1) What Mr Pascall saw in 1996 was not what was found in 1997.

(2) The claimants' own evidence demonstrated a change of levels; thus there was a contradiction at the heart of the claimants' case.

(3) The blindings uncovered below the foundations in 1997 were substantially thicker than the blindings that had been laid in early August 1996.

(4) The excavation into which Mr Pascall stepped on 23rd July 1996 was at a higher level than the formation uncovered in 1997.

(5) NSBC records showed that further excavation was done at G2 and G5 after Mr Pascall's inspection.

(6) Moreover, the claimants needed to prove that Arup's alleged negligence was an effective cause to the settlements. If notwithstanding the requirements of the design in note 5, the contractor proceeded to construct on formations that did not have a valid approval, such causation was negatived. The design was only intended to be used in conjunction with inspection and approval of the actual formations.

66. Arup's written submissions say that the judge did not properly address these questions. It is further said that none of these depend on whether Professor Hudson's theory to explain the settlements was correct. They say, however, that the judge was wrong and unfair to adopt Professor Hudson's theory. Mr Bartlett also emphasised orally the case that the settlements had resulted from damage by blasting. He needed, I think, to do so, because the direct evidence that the foundations were on poor in situ ground – derived from Arup's own December 1997 report – was compelling. The judge might have been persuaded to reject this evidence. But he did not do so, and a case on appeal that he was wrong is decidedly tenuous.

67. Arup point out that the foundations failed under a tiny fraction of the design load. Mr Pascall had inspected the G5 formation on 23rd July 1996 and concluded that it would bear the design load of 3MPa. It was not a cursory 3 minute inspection. If Mr Pascall was, as the settlements might demonstrate, wrong, there were two possibilities – either (1) Mr Pascall was grossly negligent, or (2) the foundations were not constructed on the formation which Mr Pascall inspected. If, as the judge held Mr Pascall's inspection was not negligent, the condition of the formations must have been different in 1997 from those which he inspected in 1996. There is a respondent's notice which in effect seeks to adopt Arup's admission that if the formations examined in 1997 were in the same condition as they were when Mr Pascall inspected them in 1996, he must have been negligent and the judge should have found that Arup were in breach of the ground investigation agreement as well as of the design agreement.

68. Arup make a detailed comparison between what Mr Pascall said in evidence he observed and what the 1997 investigation revealed. Mr Pascall assessed the G5 formation to be Grade III generally with weaker areas to the north east and south west corners. There was no gravel or fill. There were no remains of explosive charges. G2 had a big lump of very strong rock in the middle. By contrast, the evidence for 1997 had G5 as generally Grade IV with no weaker areas. There was a significant quantity of loose rock and gravel. Explosives were found and a detonator cord was caught in the blinding concrete. There was no lump or layer of strong rock in G2, which was of consistently poor weak soil.

69. Arup complained that, although the judge considered Mr Pascall's evidence, he made no finding about this striking contrast, beyond concluding that Mr Pascall was not negligent. What the judge actually said, in paragraph 218 of his judgment, was that he was not prepared to make other positive findings on the basis of a recollection many years later of events which Mr Pascall had no cause to remember until over 9 months after they had happened and which had no particular significance at the time. The judge was not therefore positively accepting the detail of Mr Pascall's evidence. It was not evidence which compelled the conclusion that the formations which he inspected had been altered subsequently. Arup maintain however that, since the judge held that Mr Pascall was not negligent, he could not avoid addressing the question how he could have missed something which would have been unmistakeable.

70. Arup's case on levels is that Mirant's own evidence established (a) a July 1996 level of -1.3mPD; and (b) a 1997 G5 formation level before settlement of about -1.5mPD. Therefore, they say, the formation level must have been deepened by 200mm after Mr Pascall's inspection. The judge, they say, did not appreciate or mention this. Neither did he address evidence of broadly equivalent measured differences in blinding thicknesses for each of G2 and G5 – see paragraph 129 of Arup's skeleton for the details. Neither did the judge address properly the contrast between Mirant's case, which required Mr Pascall to have stepped down 750-700mm into the G5 formation with his evidence that he remembered a depth of 300-400mm. The judge was not prepared to accept this evidence in the absence of contemporaneous records (paragraph 214). But the judge made two errors. In paragraph 214, he referred to "the blinding" when he probably meant "the formation". I regard this as immaterial. In paragraph 210, in reciting Mr Pascall's evidence, he wrongly translated 300mm and 600mm into 1¼ inch and 2½ inch respectively – a potentially material error, if that was his perception. Arup point out that it was not put to Mr Pascall that he stepped down 750-800mm and that, since G5 was the only foundation which Mr Pascall inspected, he had reason to remember it. A step down of 300-400mm was consistent with 1996 evidence of the depth to which the G2 and G5 formations had been taken. This included a quantity surveyor's record that further excavation of 3.8m³ was carried out to Unit 1 F8 bases in the first half of July 1996 to correct an earlier incorrect depth of -1.0mPD.

71. Arup say that this all supports the conclusion that the 1997 formation was about 450mm lower than the July 1996 formation. They say that the judge was not justified in holding that it was not credible that a discovery that the levels were incorrect for the second time, the removal of the blinding, re-excavation of the foundations and subsequent reblinding all happened without being recorded in any document. The extent of missing documents was very considerable – see paragraph 141 of Arup's skeleton for their details. There were in particular sufficient gaps in the quantity surveying records for deepening of the excavations to have taken place without appearing in the records that were produced. In addition, Arup say that there are records which do show that 133m³ was excavated from G2 and G5 between 15th July and 15th October 1996. There was no suggestion that this was done between 15th and 23rd July 1996. Arup say – unconvincingly, in my view – that there is a clear gap in the records between 18th and 21st September 1996 during which re-excavation of the G2 and G5 foundations, including blasting, could have occurred.

72. It will be recalled that Mirant's pleaded case as to the ground conditions as they were in 1997 derived from Arup's own December 1997 report, which had concluded that the cause of settlement was weak ground which may have been affected by blasting. In paragraph 481 of his judgment, the judge considered expert evidence, mainly from the cross-examination of Dr Endicott, in which, speaking generally, it was accepted that Mirant's case as to the ground conditions pleaded in paragraph 58.8 of their Particulars of Claim was established. The judge identified the principal question here as being whether the ground was in situ ground, or ground which had been filled by soil or boulders or had been damaged by blasting. This, he said, was the heart of this part of the case.

73. The judge then in paragraph 483 made a series of factual findings. These included that the foundations of G2 and G5 had originally been excavated to a wrong level and orientation. Re-excavation was taking place on 15th July 1996 and the formation to G2 was recorded as completed by 23rd July. The same must, incidentally, have applied to G5, which Mr Pascall inspected on that day. Blasting took place on other parts of the site on 23rd July.

Blinding took place at G2 and G5 on 8th and 9th August 1996. There was evidence – a photograph – that the blinded formations of G2 and G5 had a cage of reinforcement on top on 27th August 1996. There was a note for 23rd October 1996 that blasting was 95% complete for Boiler Unit 1. But no one gave evidence of relevant blasting between 8th August and 26th September 1996. The judge accepted Mr Brice's evidence that he did not recall G2 or G5 being blasted after 23rd July 1996. He rejected Mr Pascall's evidence in relation to the supposed step into the foundation of G5 in relation to Arup's claim that G5 was lowered or blasted after 23rd July 1996. The judge also found that some very limited blasting took place in the vicinity of Boiler Unit 1 after 23rd July 1996. But there was no clear evidence which would enable him to find on the balance of probability that the levels of the G2 and G5 foundations were altered after Mr Pascall's inspections in July 1996. He concluded that blasting was very substantially completed in the area of the boiler house by 8th or 9th August 1996 when the blinding was completed. He concluded that the movements of G2 and G5 were not caused by blasting or infill. He concluded, accepting the evidence of Dr Hencher and Professor Hudson that the ground at G2 and G5 was much poorer and uncertain geologically than Arup realised. Dr Endicott had to accept that a significant part of the rock mass was Grade IV to VI. Further the rock was foliated.

74. The judge's summary conclusion in paragraph 509 was: *"I have concluded that the formation levels were not lowered after 23rd July 1996. I have also concluded that the ground that was found beneath the foundations G2 and G5 in 1997 was in situ ground. Paragraph 58.8 of the Particulars of Claim identified the physical properties of the ground both in July 1996 and in May 1997. I have specifically rejected Arup's contention that the damage was caused by damage through blasting or the use of fill or loose rock fragments in so thin foundations."*

He added in paragraph 510: "In so far as it is necessary to elaborate how the movement of the foundations occurred, I accept the theory of Professor Hudson, set out in his evidence, as being on the balance of probabilities the most likely explanation."

75. Arup maintain that the in situ ground conditions for which Mirant, through their experts, contended could not explain the magnitude of the settlements which occurred. They say that an explanation to the settlements was required, but that Professor Hudson's theory of crossing zones of weak material was not fairly open to the judge. They say that this theory was not clearly articulated in his report. It only became clear during cross-examination when he made a sketch to explain what he meant. The theory was not part of Mirant's pleaded case, which they did not apply to amend. Nor did they adduce factual evidence to support the theory. Professor Hudson had not been to the site. Dr Endicott was cross-examined about Professor Hudson's theory, but only very briefly. He regarded the theory as most unlikely. Arup referred in closing to certain aspects of the evidence in support of the unlikelihood of the settlements having a geological cause. They objected that Professor Hudson's theory was not pleaded. The judge did not deal with the objection. He found that the theory was the probable explanation without identifying any evidence which supported it.

76. Arup contend that, if Professor Hudson's theory had been put forward in a proper manner, there would have been numerous points to be made against it. These are developed in paragraph 170 of Arup's written submissions. In the circumstances, Mr Bartlett submits that it was unjust to use the theory to find against Arup. In addition, since the collapsible zones which the theory postulated would not have been observable from the surface mapping and inspections which Dr Redding had envisaged, any negligence by Arup could not be a cause of the settlements. Arup further say that any failure by them should not be regarded as a cause of the settlements, when the inspection of the formations which they specified cannot have been properly carried out by NSBC or CEPAS. Arup did not themselves inspect G2. Mr Pascall's approval of G5 was not a relevant approval, since blinding was not placed immediately after it. It should have been re-inspected before the subsequent blinding, not least because a typhoon had intervened. The judge did not deal with this submission.

77. Arup say that the judge did not properly assess the evidence for blasting and fill at G2 and G5. Explosive was found 300mm below the blinding in the south west corner of G5 and a detonator cord was caught up in the blinding. These indicated either that G5 had been blasted, or that it had been filled with material which included these objects. Arup's blasting expert, Mr Paine, considered that the most probable explanation was that G5 had been reduced by blasting and that one charge did not fire. If by contrast the material was fill, this would be because there had been over-excavation. This could also explain the increased blinding thickness. These things had happened elsewhere on the site. The judge's finding in paragraph 483 of the judgment, leading to his conclusion that there was no relevant blasting, contained errors and misunderstandings and was flawed. There were indications in the 1997 observations which were consistent with Arup's case. These, taken with the improbability of Mr Pascall having been grossly mistaken, should have led the judge to find in Arup's favour on this issue.

78. Mirant say that the essential contest as to causation concerned the question whether the ground beneath the foundations when they settled in 1997 was in situ ground or not. They say that Arup's case never rose above the theoretical and that they never engaged with the evidence that described the physical characteristics of the ground which were actually observed and recorded. The 1997 investigations included trial pits beside the foundations to depths below the blindings; bore holes beside the formation; and mapping of the surface of the formations after the foundations had been removed. The results were recorded and considered in Arup's December 1997 report. Mirant say that Arup were almost silent as to this evidence. Clearly, if the ground was in situ, the settlements cannot have been caused by fill. Arup had to show that the ground beneath the foundations

was fill or that it had been damaged by blasting. Mirant say they failed to do so, and that the evidence in support of the judge's conclusion was overwhelming.

79. Mirant say that, as to G2, the reported findings of the December 1997 report did not suggest that the underlying ground was fill and Arup's geologists did not then think it was. In so far as Dr Endicott considered that the ground beneath the blinding in the western trench of G2 was fill, this was slenderly based on his examination of a photograph, and was contradicted by other evidence and opinion. As to G5, the reported findings all suggested in situ ground. Arup had considered at the time that blasting may have contributed to the settlement and that Trial Pit 7 on the south side of G5 indicated a layer of loose rock. But Arup had been unable to reach a concluded view then and Dr Endicott accepted that the evidence, other than Trial Pit 7, showed that the ground beneath G5 was in situ ground which was not blast damaged. The details are in paragraph 103 of the respondents' written submission in sub-paragraph (c) under the heading "In Relation to G5". Trial Pit 7 alone was incapable of supporting any theory that there was blast damaged rock beneath the whole of G5. Dr Endicott accepted that there would need to be fill or blast damaged rock beneath G5 to a depth of 1.5m to cause the failure. There was no evidence of this. In any event, the photograph of Trial Pit 7 did not clearly show fill or blast damaged rock. As the judge found, Dr Endicott agreed in evidence that all the physical characteristics of the ground alleged in paragraph 58.8 of the Particulars of Claim existed in 1997.

80. Mirant say that Arup had to show that, not only had G2 and G5 formations been lowered, but that they had then been raised again with fill or at least over blasted. The physical examinations of the ground in 1997 showed that both these possibilities were wrong. Arup's arguments were based on theories which ignored the physical evidence. The judge was not plainly wrong to accept the physical evidence in preference to the theories.

81. As to Arup's submissions based on levels, including Mr Pascall's step down, there was no direct evidence of the precise level of the site next to G5 in July 1996. Dr Endicott accepted that there was a doubt about whether the levels changed and that care should be taken in making deductions. Mr Pascall's own evidence was that he did not make a clean step down. It was something of a scrappy bit of a shape. He was recalling events 7 years earlier. The judge was entitled to find that his evidence was unreliable. The judge's conversion error does not invalidate his finding that the ground was in situ. It was unlikely that the judge mistakenly thought that Mr Pascall was taking a step down of 1¼ inches, which was on any view scarcely a step at all. Mirant say that this error could have been clarified, if Arup had raised it when they received the draft judgment. Although Mirant accept that there is a lack of contemporary records, they submit that known facts make it most unlikely that the G2 and G5 formations were re-excavated after 23rd July 1996. Blinding was poured by 9th August 1996 and reinforcement was in place on 27th August 1996. Re-excavation would require dismantling the reinforcement, removing the blinding, re-excavating, re-blinding and re-positioning the reinforcement and the holding down bolts. There is no evidence that any of this happened, nor, say Mirant, do Arup identify the times when it happened. Mr Brice, who was on site from June to September 1996, did not recall G2 and G5 being lowered or blasted.

82. Arup suggest that the re-excavation took place between 23rd July and 15th October 1996 – this from the record of 133m³ of material being claimed for payment. Yet evidence inconsistent with this positively accounts for the whole of the period and more – blinding 9th August; photograph 27th August; dismantling of reinforcement and holding down bolts 2nd September; excavation for working space and stub settings 28th August to 4th September; blinding stub settings 9th September; installing holding down bolts 24th September; Mr Hontucan on site 23rd to 26th September, no evidence of lowering G2 and G5; he took photographs; reinforcement installed 7th to 9th October; structural form work 12th to 19th October; survey of holding down bolts between 1st and 20th November, discrepancies rectified; formwork removed and anchor bolts realigned about 20th November; more trouble with formwork and holding down bolts 23rd November to mid-December; concrete poured 23rd January 1997. The references for all these are in paragraph 116(4) of Mirant's written submissions. I have not personally checked them all, this appeal being a review. But the details provide a solid basis for the judge's conclusion that G2 and G5 foundations were not re-excavated or blasted as Arup suggest.

83. As to the 133m³ of excavation for which the contractor claimed, Mirant point out that the claim did not state that it came from G2 and G5, nor that fill was placed below these foundations. They say that the site records did show excavation in the vicinity of G2 and G5, although not beneath them. This was for stub settings and working areas. Mirant also say that 133m³ does not correspond with a sensible calculation of what might have been excavated from G2 and G5. They say that the claim may be seen as the difference between control and measured excavation.

84. As to Arup's argument about the thickness of blinding, Mirant make various points, the more persuasive being:
    a) There is no documentary evidence that the blinding poured between 6th and 9th August 1996 was later dug up and re-poured, nor any quantity surveyor's records pointing to unaccounted for quantities of blinding.
    b) Arup compare an average thickness against an actual thickness at particular points on two of four sides only of the formation. Records show that the blinding was of variable thickness.

85. As to Arup's argument postulating over blasting and fill, Mirant say that this is a variant of the re-excavation theme. It fails upon the judge's finding that the ground was in situ; because Dr Endicott did not consider that the settlement was the result of blast damage; and because there was positive evidence, which I have referred to above, that there was no relevant blasting after 23rd July 1996. The last two points also apply to the theory that the ground beneath G2 and G5 was damaged by blasting in the near vicinity, a case which Mirant say Arup did

not maintain before the judge. Arup's blasting expert, Mr Paine had originally concluded that there was no evidence of blast damage beneath G2 and G5. In a supplemental report, Mr Paine took account of further documents, but did not positively conclude that there was blast damage beneath G2 and G5. All he could say was that it was a possible explanation for some of the evidence he had seen. Another possible explanation was damage done by mechanical excavators during the 1997 investigations, which was Dr Hencher's preferred explanation for evidence of fracturing in the ground. Neither Mr Bowden nor Mr Higson, who had seen the ground in 1997, could say whether what they saw was blast damage or damage by mechanical excavators.

86. As to the explosive and detonator cord which were found, Mirant make a number of points, the more persuasive of which include that there was no dispute but that the boiler house area was blasted generally. Blasting was carried out to remove the hill. The explosive and detonator may have been left over from that operation, and Mr Pascall may not have noticed the detonator cord on 23rd July 1996.

87. Mirant say that the fact that the settlements occurred at very low loads establishes no more than that the ground beneath the foundations was very weak. They say that Professor Hudson's theory was not necessary to the judge's decision. The judge observed that it was on the balance of probabilities the most likely explanation in a one sentence coda to his judgment. The essential decision was that the ground was in situ. Professor Hudson's theory was entirely consistent with the ground conditions identified beneath the foundations, the main features of which are listed in paragraph 25 of Mirant's closing rebuttal submissions before the judge.

Grounds of appeal

88. There are essentially two grounds of appeal. These, in short form, are that:

(1) The judge was wrong to hold that Arup had a duty under the design agreement to verify the 3MPa design assumption and that they were in breach of their duty;

(2) The judge's decision as to the causation of the failure of G2 and G5 was wrong.

89. The first ground proceeds in part on a misunderstanding of what the judge held. It is suggested that the judge held that Arup were under an obligation themselves to carry out the necessary verification on site. As I have indicated, the judge did not so find. He held that Arup's obligation was to see that work to verify the design assumption was undertaken by someone; and that appropriate work was not undertaken either by Arup themselves or by anyone else.

90. It will be remembered that the Technical Site Supervision section of the May 1995 proposal had been omitted from the design agreement. The omitted section had included a role for the small team of engineers to "confirm that the design intent is being fulfilled", and that they would approve formations for construction. It is Arup's case that confirming that the design intent was being fulfilled would have embraced verifying the foundation design assumption of 3MPa, and that the omission of this section from the design agreement meant that Arup were not obliged to verify the foundation design assumption under the design agreement. It is further Arup's case that the function of the site foundation engineer under the ground investigation agreement of approving ground conditions for foundations embraced verifying the foundation design assumption, and that, since the agreement was varied so that they were only obliged to approve foundation formations if they were asked to do so, absent such a request they had no obligation under either agreement to verify the foundation design assumption. The judge rejected each of these submissions, correctly in my judgment.

91. I reject Arup's grounds of appeal which say that the judge was wrong for these reasons:

(1) Arup were obliged under the design agreement to carry out their design with the skill and care of ordinarily competent engineers for work of this kind. This is not contentious.

(2) A competent foundation design requires a sufficient knowledge of the ground conditions to determine a safe bearing capacity for foundations.

(3) If the designing engineer's knowledge of the ground conditions is insufficient to enable him to determine a safe bearing capacity, he may work initially upon assumptions. But he has an obligation to see to it that the requisite additional information is acquired to verify the assumptions. He does not necessarily have to get the additional information personally, but he must see to it that someone does, and he must see to it that the client knows that the additional information has to be obtained. Absent an explicit warning and disclaimer, it would not be sufficient for a designer, whose initial design is based on an unverified assumption, to leave it to the client alone to obtain and evaluate the additional information. The designing engineer is responsible for the design, and he should normally see to it that the necessary additional information is conveyed back to him, so that he may judge that it is sufficient for the purpose of his design.

(4) I do not construe the words "confirm that the design intent is being fulfilled" in the omitted part in the May 1995 proposal as embracing verification of the foundation design assumption. In the context of site supervision, this meant seeing that the contractor is building in accordance with the design intent. I do not consider that any contrast with the "approval of formations for construction" yields a more extended meaning.

(5) In any event, omission of the Technical Site Supervision section did not diminish Arup's obligations as designers.

(6) I do not construe the words "approving ground conditions for foundations" in the ground investigation agreement as extending to verifying the foundation design assumption. This again was a site supervision obligation.

(7) Arup's submissions suppose – and on the facts need to suppose – that verification of the foundation design assumption only required surface examination of the foundation formation such as a site supervisor would

habitually do. There may be many contracts for which this might be sufficient, but not, on the facts, this contract. Dr Redding's and Dr Oldroyd's evidence made it quite clear that more extensive investigation, such as I have briefly described, was here needed. The judge so found – see paragraphs 194, 213 and 451 of his judgment. He was on the evidence, including the expert evidence, right to do so. Appropriate additional information sufficient to verify the foundation design assumption might have come from the geotechnical and geophysical investigations which Arup undertook to supervise. But, in the event, those investigations yielded little that was relevant.

(8) I accept Arup's submissions that foundation design is not an exact science, and that perfect and complete knowledge of the ground may be impossible to achieve. That does not, however, mean that a foundation designer does not have to see to it in appropriate circumstances that his assumptions are verified to the extent that a reasonably competent design would require. The judge had ample evidence to determine, as he did, what the required extent was in this case.

92. It is Arup's subsidiary case that, if they were under an obligation to verify the design assumption, the obligation arose under the ground investigation agreement, and that they duly performed this obligation for G5 by Mr Pascall's inspection of it. The judge was, in my judgment, correct to hold that the activities which Mr Manning and Mr Pascall performed under the ground investigation agreement were different in kind from those required to verify the design assumption. It was possible that proper supervision of a different and more extensive ground investigation with particular reference to G2 and G5 (which was not undertaken) would have yielded information capable, depending on its nature, of verifying the design assumption. But this did not in fact happen. Nor would this have affected the obligation arising under the design agreement to see that the design assumption was duly verified.

93. Arup make other points as follows:

a) they say that the judge misunderstood and misused an Arup internal memorandum dated 1st September 1995. This submission refers to paragraphs 30 to 38 of the judgment. I find this entirely unpersuasive. The judge's decision was justified and correct without reference to this document on the straightforward lines indicated in paragraph 91 above.

b) Mr Bartlett submitted that what may at one stage have been a provisional design ceased to be so when CEPAS instructed Arup to proceed with the detailed design and to issue it to the contractor for construction. I find this entirely unpersuasive. Such instructions did not absolve Arup from producing a proper design. A proper design required verification of the design assumption.

c) Arup explicitly qualified their design by Note 5 on the relevant drawing which stated "Bases to be founded on unfractured rock. All formations to be approved by CEPAS …". This was, they say, well known to CEPAS. This note was not, in my judgment, sufficient to perform or otherwise get rid of Arup's obligation as to verification of the design assumption. It was essentially an instruction to the contractor. The judge was entitled to hold both that it was Arup themselves who needed to be satisfied that a sufficient verification process had been undertaken, and that superficial site inspection of the formation was insufficient for this purpose.

94. Arup make numerous other criticisms of the judge's judgment with reference to his finding that they were in breach of the design agreement. Here and elsewhere they point to what they say were numerous errors, born, they say, of the time which it took the judge to write and hand down his judgment. Many of the errors are insignificant. The true heart of the matter is, however, Arup's contention that the judge was wrong to reject their case that Mr Pascall's inspection fulfilled such verification obligation as they had. This mis-characterises the nature of the obligation. The judge was, as I have indicated, entitled to hold that verification of the design assumption required more than could be achieved by surface examination of the formations only. Arup failed adequately to see that their design assumption was duly verified, and were accordingly in breach of the design agreement. I would reject this ground of appeal.

Causation - discussion

95. The main ground of appeal here is that the judge should have held that G2 and G5 failed because they were founded on fill and/or ground which had been weakened by blasting after Mr Pascall's inspection. I have summarised the detail of Arup's submissions and of Mirant's answers to them earlier in this judgment.

96. It is, I think, necessary to stand back from the welter of detail, otherwise there is a danger of being swamped. The judge was, in my judgment, correct to identify the crucial question as whether the ground found beneath G2 and G5 in 1997 was in situ ground. If it was, then for one reason or another it was very weak ground. The judge had a difficult decision to make, because it was not perhaps possible to reconcile and explain every strand of the evidence. Human nature strives in circumstances such as these to find a coherent explanation for everything. Sometimes this is not possible, so that it is necessary for a judge to choose which of two or more conflicting strands of evidence is more persuasive. In the first instance, that is the prerogative of the judge who hears and evaluates the evidence, especially in the Technology and Construction Court. I have already indicated that a party seeking to persuade this court that findings of fact by a specialist TCC judge were wrong has an uphill task.

97. The judge was, in my view, entitled to hold that the evidence from the 1997 investigations established that the ground beneath the G2 and G5 foundations was in situ ground. This was direct evidence gleaned for the very purpose of saying why the foundations had failed and to design remedial works. Arup themselves at the time had in effect concluded in their carefully drafted December 1997 report that the ground was in situ, although they said it had been weakened by blasting. The case that the foundations had been built on fill had scarcely any

evidential support other than perhaps an inference from the detonator cord that was found. Mr Bartlett concentrated his latest submissions before us more on blasting.

98. As to blasting, there was admittedly a lack of records between 23rd July and the autumn of 1996. On the other hand, there was evidence (to which I have referred) from one source or another of a series of activities at or related to G2 and G5 during the relevant period which scarcely left any period of time during which unrecorded relevant blasting might have occurred. Mr Bartlett was driven back to 16th or 18th to 21st September – an unduly short period in my view, to accommodate all the relevant necessary operations. So the judge was entitled to hold that there was no relevant blasting. This, with the finding that the ground was in situ, made a sufficient case for the judge to be entitled to hold that Mirant's case on causation succeeded.

99. There were indications arguably pointing to a different conclusion. Of these, those which depended on the detail of Mr Pascall's evidence were insecure, since the judge in effect held that his recollection was unreliable. On the other hand, there was force in the general point that, if the ground was as weak as was alleged, Mr Pascall must have spotted it. The judge's misconversion from millimetres to inches is worrying, because it could be taken as indicating a relevant misunderstanding of part of Mr Pascall's evidence. But it is one point among many, and I am not persuaded that it undermines the judgment as a whole. There are points to be made about blinding thicknesses and depths beneath site formation level. But they are at best inferences and they do not, in my view, trump the really quite strong evidence that the ground was in situ and that there was no relevant blasting.

100. As to Professor Hudson's theory, Arup, I think, complain too loudly. The theory does appear in his report and Arup themselves explored it in cross-examination, so that they understood it. Explaining the very weak in situ ground was not an evidential necessity, although it was no doubt intellectually satisfying to try. The judge adopted Professor Hudson's theory, as he was entitled to do on the evidence, very much as a shortly stated coda.

101. Finally, I consider that the judge, having found that the ground was in situ, was entitled to conclude that Arup were in breach of the obligation in the design agreement to verify the design assumption. The ground beneath the foundations which the 1997 investigations revealed was very weak. Evidence to support Professor Hudson's theory may not have been visible at the surface. But there was evidence to support the conclusion that a proper site investigation to verify the design assumption would have revealed that the ground was weak. If the logical extension of this was that Mr Pascall did not do what he did carefully, so be it. But it was not necessary for the judge so to find, because he correctly found that Mr Pascall was not there to undertake the proper verification investigation. Arup's related submission that their breach of duty did not cause the failure because proper site inspection of the formations was not undertaken after Mr Pascall left the site also, in my view, fails to absolve them from their breach. This again founders on the misconception that site inspection of the formations was sufficient to verify the design assumption.

102. I conclude that the judge's factual findings as to causation were justified and are not amenable to appeal.

Conclusion

103. For these reasons, I would dismiss this appeal.

Lord Justice Richards:

104. I agree.

Lord Justice Mummery:

105. I also agree.

Andrew Bartlett QC and Ian Wright (instructed by Messrs Beale and Company) for the Appellant
Andrew White QC and James Howells (instructed by Messrs Pinsent Masons) for the Respondent