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CIVIL ENGINEERING STATUS REPORT FOR THE CMS WORKSITE

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Abstract

Civil engineering construction started at Point 5 in 1998 using a contract based upon the standard FIDIC model (Fédération Internationale des Ingénieurs Conseils). The new surface buildings and underground structures are necessary to accommodate the CMS detector for the LHC Project. The principal underground works at Point 5 consist of two new shafts, two caverns along with a number of small connection tunnels and galleries. At Point 5, the works are now 90% complete. Three surface buildings are due to be completed in 2004, namely the SX extension over the PX56 shaft, including the 'Bouchon', and also the SCX and SDX buildings. Underground, the USC55 cavern secondary lining is now complete and the UXC55 cavern lining due for completion in the summer of 2004. The aim of this paper is to present the status of the civil engineering on this worksite and in particular the challenges encountered during construction and experience gained using a FIDIC based contract.

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1 INTRODUCTION

The civil engineering works for the LHC Project are divided into four main Packages. Package 02 consists of all the underground and surface works at Point 5 necessary to accommodate the CMS detector. This paper will present the status of this worksite since the start of construction in 1998.

In April 1996, the design and supervision was awarded to Gibb(UK), SGI (Switzerland) and Geoconsult (Austria) for approximately 12MCHF. After tender negotiations the construction contract was awarded to a joint venture of Dragados (Spain) and Seli (Italy) in May 1998 and work on site commenced 31 August 1998.

The principal surface works consist of the partial demolition of existing surface buildings to make way for the new 140m long SX5 building for the detector assembly. This building has two 80t cranes internally and a large temporary external crane over the shaft for lowering the detector sections, weighing up to 2500t each. Due to the high loadings from the detector, the floor slab needs to have piled foundations. Other new buildings include the SF5 for cooling & ventilation, SGX5 for gas supplies, SUX5 for ventilation, SCX5 for offices, SH5 for cryogenics, SDX5 over the smaller access shaft and the SY5 building for security control.

The principal underground works at Point 5 consist of two new caverns, two new shafts of 20.4m and 12.0m internal diameter, a number of smaller connection and service galleries and tunnel enlargements on the existing LEP. The new experimental cavern UXC55 (26.5m wide and 24.0m high) and the service cavern USC55 (18.0m wide and 14.0m high) are parallel and in close proximity of each other. The rock cover to the main cavern is only around 20m with an overburden of about 50m of water bearing moraine above. To allow excavation of the shafts to proceed it is therefore necessary to freeze the ground, with excavation and lining in stages and a second lining added later. The main features with regard to special construction techniques is that it is necessary to replace the rock between the two caverns with a 7m thick concrete support pillar and that the works must proceed in conjunction with LEP operations until final shutdown.

All the spoil generated from the excavation will be permanently stockpiled on the site in accordance with the requirements of an external landscape architect. This will considerably reduce the amount of construction traffic on the public road network.

The procedure to be adopted in the settlement of disputes that may arise is clearly laid down in the contract. The most common kind of dispute occurs when the Contractor claims payment for expenditure he has incurred, or loss he considers he has suffered, on account of circumstances which he considers he could not have been expected to allow for in his tender. Initially the Engineer must decide whether or not there is provision in the Contract under which he can certify this expenditure for payment by CERN.

Should the parties fail to reach a settlement on a claim then a second stage dispute resolution mechanism has been included in the Contract. A panel of Adjudicators (independent experts experienced in dispute resolution) will provide a decision. Five consultants were appointed and depending on the dispute either one or three members will be utilised to form a panel to adjudicate such a difference or dispute. Any appeal from this decision will only be possible after the completion of the works when Arbitration can be used. However, negotiation and settlement is usually preferred and arbitration is considered as a last resort.

2 SURFACE WORKS PROGRESS

The SX5 building was handed over to CMS on schedule at the beginning of 2000. At the same time the SH5, SD5 modifications and the SY5 building were also handed over along with the associated technical galleries and access roads.

Subsequent to these structures, the contractor started construction of the SF5 and SUX5 buildings for cooling and ventilation. The SUX building, which is adjacent to the new PM54 shaft was delayed due to the problems encountered with the ground freezing. However, both building were completed along with the foundations for the helium tanks by mid 2001.

Originally the SGX5 building for gas supply was not due for completion until the end of 2003. However, this structure was also handed over in mid 2001.

The outstanding surface works consist of the prolongation of the SX5 building over the PX56 shaft, the SDX5 building over the PM54 shaft and the SCX5 building for the physicist's controls. The construction of these remaining surface building is on-going and due for completion by the end of 2004 / start of 2005.

3 UNDERGROUND WORKS PROGRESS

3.1 Shaft Construction

It was decided to utilise the technique of ground freezing to enable the construction of the two new shafts. The shafts are approximately 100m deep and pass through approx. 50m of mainly sandy gravel material, namely Moraine before reaching the Molasse rock. Aquifers exist in the upper and lower gravel strata.

The basic principle of ground freezing is to remove heat from the ground until the temperature is below the freezing point of the groundwater system, allowing a vertical cylindrical ice-wall to form around the perimeter of the shaft prior to excavation. In order to achieve this it was necessary to drill and install freeze pipes around the perimeter of the shafts in order to reach the Molasse. Brine was then circulated in the freeze pipes at a temperature of around -23°C in order to achieve an average frozen ground temperature of approx. -10°C . The refrigeration plant consisted of compressor system charged with ammonia. Due to the noise emissions from the plant a concrete block wall was erected around the installation.

Pre-grouting was performed in order to combat the effect of groundwater flow in the existing aquifers in order to reduce the velocity of the water to acceptable levels. This grouting of cementitious bentonite mixture was controlled using a volume and pressure criteria.

Brine circulation started in April 1999 around the smaller PM54 shaft and by the end of June the ice wall was substantially complete. Similarly, by the end of 1999 for the PX56 shaft. However, due to the unexpected high velocity of the existing groundwater in very small and isolated pervious gravel channels it proved very difficult to close the ice walls 100%. With a combination of liquid nitrogen injection and additional grouting both shafts were successfully frozen allowing excavation of both of the shafts to be completed mid 2000. Both shafts then had their definitive secondary linings installed using the slip forming technique, allowing the ground freezing to be switched off.

The Contractor issued a Notice of Dispute to the Panel of Adjudicators for the delays and costs incurred due to the difficulties encountered during the shaft freezing process. The Adjudicators determined that the Contractor was entitled to approximately 70% of his claimed costs and an extension of time of 155 days.

3.2 Pillar Construction

It was necessary to replace the relatively weak Molasse rock between the two new caverns with a 7m thick concrete pillar prior to allowing excavation of the caverns to commence. Upon completion of the PM54 shaft it was possible to start construction of the pillar in mid 2000. Originally the Contract foresaw that the Pillar should be constructed from the bottom up in a series of 'drift' excavations followed by concreting prior to started the next 'drift' in order to restrict movements in the LEP tunnel. Due to revised timing of the LEP shut down an alternative method of construction was accepted whereby the pillar was 100% excavated prior to filling with concrete. The pillar excavation was complete by March 2001 and filled with concrete by September 2001.

The Contractor issued a Notice of Dispute for the delays encountered during the Pillar construction. The Adjudicators more or less agreed with CERN's determination for additional costs and extension of time.

3.3 Cavern Construction

Instrumentation results both during and after concreting of the pillar indicated unexpectedly high movements in the side walls of the pillar. This led to a review of the underground design and to certain changes being introduced to the primary and secondary linings of the caverns. For example, the thickness of the shotcrete linings and the capacity of the rock bolts were increased.

The first activity in each cavern was to construct an anchored shotcrete ring at the intersection between the shafts and the cavern vaults using post tensioned rock bolts. Then the excavation of the top headings started at the end of 2001.

Four further drifts were excavated for the UXC55 Cavern followed by the construction of the 3m thick reinforced concrete invert. This invert was excavated and then concreted in five bays to reduce ground movement. Further to the re-design for the caverns, heavy reinforcement was introduced into the inverts and the sidewalls which has led due to substantial delays being incurred.

At the time of writing this paper the wall concreting for the UXC cavern is approx. 90% complete after which the concreting for the crown will commence. Concreting for the cavern is due to be complete by the end of the summer 2004. The USC cavern is 90% complete with the US54 sub-cavern still to be lined and the concrete finishing works outstanding. This cavern is due to be handed over to CERN at the start of the summer 2004.

Discussions are on-going between CERN and the Contractor to assess the impact on the programme and costs for the changes made to the Caverns design. It remains to be seen whether a negotiated settlement can be found or if the dispute will be referred to the Panel of Adjudicators.

4 CONTRACTUAL LESSONS LEARNT

The most difficult problems that have arisen for CERN have been issues relating to design responsibility and how to deal with issues where the consultants are implicated. The contracts are written on the basis that the consultants manage the contracts with minimal technical input from CERN. This puts CERN in a position where we rely heavily on the consultants. This causes problems when situations arise that may be partly the fault of the consultant since CERN is left in the position with no one to assist in defending their case. The very limited internal resources available compound this problem. Even worse is the potential scenario whereby a costly problem arises that all three parties consider to be the fault of one of the other parties. In this situation CERN may find itself not only fighting against the contractor but also the consultant.

A possible improvement might be that in future contracts the consultants have more responsibility for the construction costs. This could be achieved by sharing of overall contract profit / loss. This would mean a greater risk sharing and inevitably lead to the consultants requesting higher fees. However, with this scenario the consultants would have more incentive to ensure that the costs remain close to the original tender estimate.

The Adjudication Procedure has already been utilised twice on the Contract for the difficulties encountered during the shaft ground freezing process and pillar construction. Both times, the Adjudication procedure laid down in the Contract was successfully executed as prescribed in the Contract, however, it remains to be seen if either party will refer the decision to Arbitration at the end of the Works.

5 CONCLUSION

At Point 5, the works are 90% complete. The underground works are due to be complete by the end of 2004 and the remaining surface building by the start of 2005. As with most large civil engineering projects, unexpected problems have arisen during the construction phase. This is despite the extensive site investigation campaign that was carried out prior to the award of the contract. However, for underground works it is impossible to predict every eventuality and it was always understood that the ground conditions at Point 5 were not the most suitable for such large caverns. Despite this the FIDIC Contract has proved flexible enough to allow major changes during construction and the Dispute Resolution Procedure has so far proved to be generally satisfactory.