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Afghanistan's only operational plant: Ghori I

Griffin Capital was appointed by a Kazakh resource developer to advise on a tender to the Afghanistan's MoM for the US$300m Ghori III greenfield cement plant project. The developer achieved pre-qualification short list approval in 2014, following a secure site inspection at the Ghori I and II plants that was arranged by Griffin Capital with the US Secretary of Defence's Task Force for Business and Stability Operations (TFBSO) and the USGS.[1] Griffin Capital's Robert Jutson agreed to provide an overview of the existing cement operations at the Ghori site, the cement industry in Afghanistan and its outlook.

Ghori cement background

The Ghori site was originally developed for cement production in 1959 by the Afghan Government. It is currently home to two cement plants, Ghori I and Ghori II, although only Ghori I is operational. The plants are located side-by-side, 200km north of Kabul in the Pol-e-Khomri District, Baghlan Province.

The Ghori I plant was commissioned in 1959 and is Afghanistan's only currently-operational cement plant. It was built by the Czech construction company Prerovske Strojirny for the Afghan Government. The equipment was supplied by its affiliate company, Perov Machinery Enterprise, as part of an economic aid package from the Soviet Union. The plant has 400t/day or 120,000t/yr of clinker production capacity, from two wet-process 200t/day capacity kilns. It is situated between a large limestone hill and the Pol-e-Khomri River (Figure 1).

The Ghori II plant was partially-constructed in 1986, but building was halted in 1989 with the Soviet withdrawal from Afghanistan. The plant has two wet-process kilns, each with 500t/day of clinker production capacity. It is equipped with technology from the Czech Republic (Prerov/Skoda) that dates back to the 1970s. The Ghori II plant remains about 70% complete. Civil work is almost finished and mechanical equipment is on site and 30% erected. Electrical work has not started, though it has been on site for 15 years: It is now deemed obsolete. The general condition of the erected parts of the plant and of the plant parts that are in storage is reportedly good.

Both plants were privatised in 2006, along with resource concessions including an 87Mt on-site limestone reserve and the Karkar-Dudkash coal mines. The Ministry of Mines (MoM) granted a concession to Afghan Investment Company (AIC) to operate and improve the Ghori I and II cement plants based on a detailed implementation plan submitted by AIC.[2]

AIC was established in 2003 in Kabul and Pol-e-Khomri. The founding shareholders included

Right - Figure 1: The Ghori I cement plant was commissioned in 1959 by the Afghan Government. It is some 200km North of the capital city, Kabul, near the Pol-e-Khomri District, Baghlan Province.

prominent Afghan businessmen and well-connected individuals. According to published reports, AIC was capitalised for US$45m, half of which was cash and half from bank loans.[3]

The Ghori I and II plants were conditionally leased by the MoM to AIC in 2006 for 49 years. The MoM sought investment and the creation of high-value jobs. AIC planned to find an investor and operator to participate in the growth of the business. The purchase and upgrade costs were estimated at US$570m. The scope involved the renovation of the two kilns at the Ghori I plant, completion of the Ghori II plant, construction of a new dry-process Ghori III plant and a new coal-fired 25MW power plant.

The contract for privatisation required AIC to deliver a massive increase in production, from 40,000t/yr to 3Mt/yr, all in accordance with the detailed AIC plan presented to the MoM. AIC agreed to quickly achieve maximum production capacity and provide a one-year notice to the MoM prior to any transfer or assignment of rights to an investor or other third party. However, no investor was forthcoming, no improvements were made to the entire Ghori site. Nor, after five years, had production increased.

As a result, in 2012 the MoM began a formal review of the terms of the AIC concession. In 2013, the MoM announced an international tender for a greenfield development project, the Ghori III cement plant, on a 30,000m^3 former clay quarry adjacent to the Ghori I and II plants. The MoM oversees the Ghori III tender and the Ghori I and II sites and operations. In 2013, Griffin Capital advised the winner of the prequalification round of the Ghori III tender. However, the process was postponed indefinitely in 2014 on the eve of the presidential elections.

Raw materials

The Ghori I plant uses a raw material mix of 30% clay and 70% limestone. The limestone/clay mixture has a moisture content of <2% and a reported sulphur content of <0.5%.

The limestone is acquired from the hillside to the west of the plant, which has around 87Mt of reserves (Figure 2). It is extracted via manual labour, using simple hand-held tools, as well as by a hydraulic crawler shovel with a 1m^3 bucket. The limestone is loaded onto 10m^3 capacity haul trucks. While the majority is fine enough to be loaded directly from the quarry onto the trucks, large boulders or rocks are reduced in size with a jackhammer or explosives. The limestone is transported some 300m to the primary crushing operation.

The clay and shale are extracted in the same way as the limestone from a deposit some 1km to the south of the Ghori I plant. It is then transported directly to the storage hall, as crushing is not required. Given the limited cement production at the Ghori I plant, clay mining operations are now performed just once per month. Gypsum comes from the Dudkash deposit some 18km away. The raw gypsum particles are <300mm in size.

Crushing operations consist of a 19t/hr capacity primary jaw crusher and a 19t/hr capacity secondary hammer mill. The primary crusher is fed from the dump pit by a pan conveyor. The lower-size material is then transferred to the adjacent secondary hammer mill by belt conveyor. The final limestone product, now <13mm in size, is transferred by belt conveyor to an open storage hall.

The quarry equipment is in sufficient condition to meet the demands of the Ghori I plant's current

Left - Figure 2: The Ghori I plant is located between an 87Mt limestone hill and the Pol-e-Khomri River. The hill and river provide a significant portion of the plant's raw materials.

production. However, to meet a production increase to the design capacity of 400t/day, equipment upgrades are required. The hydraulic crawler shovel, the air compressor and the haul trucks are in poor condition. In contrast, the crushing equipment is in good repair and is designed to supply processed raw materials for 400t/day of clinker production.

The storage hall is a 25m x 160m open concrete structure serviced by two bridge cranes. The two 10t bridge cranes are used to distribute the materials and service the mill feed hoppers as required. One of the two cranes is currently inoperable due to electrical problems; it requires repairs to support increased production. There are also some structural repairs required to the hand rails and walkways. The hall can store 30,000t of limestone, 10,000t of clay, 5000t of coal, 15,000t of clinker and 5000t of gypsum.

Water for the wet-process kilns is withdrawn from the adjacent Pol-e-Khomri River. Process wastewater is discharged into the same river. Information on current process water withdrawal and discharge rates, as well as source and discharge water quality are not available. However, facility personnel believe that there is sufficient flow in the river to support cement production at the Ghori I plant when it is operating at full capacity.

Below - Figure 3: The raw materials are processed in one of the two 200t/day capacity 3.1-2.7m x 95m wet-process kilns. Only one kiln is currently operational at the Ghori I plant due to poor coal supplies.

Bottom - Figure 4: Both of the wet-process kilns have satellite coolers for clinker cooling.

Process and production

The Ghori I plant has two 20t/hr 2.2m x 13m single compartment ball mills for raw material grinding. A 630kW motor with a liquid rheostat starter powers each mill. The clay and limestone are metered from the feed bins to the mills by table feeders. Water is added to the raw mills manually to achieve targeted moisture of 35%. The feeders are adequate, but in poor repair and therefore suspect in reliability. Both of the raw mills require liners, discharge screens and a ball charge. The drives, gears and bearings are in good condition with only minor repairs and maintenance required. Griffin Capital could find no process controls for fineness, moisture or chemistry.

The slurry is discharged from the raw mills into an open trough to a sump, which pumps it to one of nine 290m^3 slurry silos. Here, the slurry is kept in suspension with compressed air. From the silos, the slurry is pumped to a paddle-type metering device atop the slurry silos, then gravity fed into the kiln entrance. There is adequate storage to support 400t/day of clinker production capacity.

Clinkerisation is performed in two 200t/day capacity 3.1-2.7m x 95m wet-process kilns with satellite coolers (Figures 3 and 4), although only one is presently used. The kilns are hydraulically-powered to open gearing for rotation. According to Jutson, all of the refractory brick in both kilns requires replacement. Additionally, the operational instrumentation is either non-existent or non-functional. The instrumentation that indicates kiln rotational speed, kiln drive amperes, burning zone temperature and kiln exit gas content needs to be replaced or supplemented. As the current practice exists, there is little, if any, feedback from the laboratory to the operator advising of clinker quality.

The clinker is dropped from the satellite coolers into a chute that loads a double chain bucket conveyor for transport to the storage hall. The bucket conveyor works well with little spillage at the current production rate. The design appears to be capable of operating at the proposed production rate of 400t/day with no increase in spillage. As with other aspects of the plant and equipment, maintenance to the clinker transport conveyor has been deferred. Secondary clinker storage also exists on a 3000m^2 site directly west of the storage hall. This clinker is reportedly turned daily with a bulldozer.

Finish grinding is performed by two 20t/hr capacity 2.2m x 13m single compartment ball mills. Each is powered by a 630kW motor with a liquid rheostat starter. The clinker and gypsum are metered from the feed bins to the mills by table feeders. The feeders are in poor repair and therefore of suspect reliability. Additionally, there is no evidence of process control for determination of cement Blaine area, sieve analysis or sulphur content.

The cement is discharged from the mills into an airslide and transported 94m to a bucket elevator, which lifts the product for storage in one of three 2000t cement silos. The cement is withdrawn from the silos through a lump breaker and into a bin that supplies cement to a four-head packer. The cement is loaded into 50kg bags that are transferred by conveyor for truck loading or stacking. There is a pipe that branches off below the lump breaker that serves as a bulk load out spout, which is required only very occasionally.

The dust collection equipment does not function, resulting in extremely high dust levels in the area, with visibility impaired to less <0.5m during packing operations. According to Jutson, at least 10% of the cement becomes airborne during the packing process at the Ghori I plant. Most of the cement dust remains in the facility and is collected using shovels for re-packaging, posing health and safety and workplace quality issues.

The packing machine is in poor repair with the counter weights held in adjustment by wire, string, rags and sack material. The packhouse is able to fill 4000 50kg bags in seven hours (Figure 5). All of the cement produced at the Ghori I plant is dispatched via truck. Each customer brings a flatbed truck to the plant loading area, where the 50kg cement bags are secured for transportation.

According to Jutson, the on-site laboratory is poorly-equipped with outdated and partially-functioning apparatus. The chemicals are well beyond their recommended shelf life and there is no climate control. Chemical testing is performed using wet analysis, while the oven for moisture analysis does not function. There is no apparatus to test Blaine fineness, setting times or pack set, while the screens for sieve analyses are badly worn. The compression testing equipment leaks oil and its accuracy is suspect. The record keeping has been sporadic and has been used solely for historical purposes. There is no evidence that analytical data has been used for process control. Physical testing consists of some sieve analysis, tensile strength tests and compression strength tests.

On a notional basis, the Ghori I plant produces 42.5 and 52.5 grade cements. However, Jutson said that there are no national cement standards. As almost all cement in Afghanistan is imported with few, if any, controls, much of the cement available in the country is substandard. Indeed, independent laboratory testing and analyses have shown that cement manufactured at the Ghori I plant is well below internationally-accepted standards (Table 1).

Ghori I operates at about 3-4% capacity utilisation. However, Jutson explained that capacity utilisation is not really meaningful, as operations are sporadic due to the unreliable coal supply. Furthermore, since maintenance expenditure on the outdated plant has for decades been virtually zero, the quantification of actual production capacity is speculative. At present, the operations are limited to one kiln, operating at a rate of 80-100t/day for a maximum of 10 consecutive days, followed by 10 days of down-time. The intermittent operation is required due to the lack of coal. This is in spite of the fact that the concession granted by the MoM includes the Karkar-Dudkash coal mines.

The Ghori I plant mainly sells to local builders. There was large demand in recent years, driven by NATO/ISAF military/civil related work, but this diminished dramatically in 2014. The Afghan cement market is also affected by seasonality. Demand falls during the winter season, in December-February, as truck transportation is challenging due to snow and severe weather. In some remote regions, transport links are entirely cut off.

Fuels and energy

The Ghori I plant runs on gas and coal, although gas is not available in large amounts. The coal is mined from company-owned coal mines, the Karkar-Dudkash mines, which are located around 20km east of the plant. The mines were established by the British in 1938, when the first and only survey was made. The coal reserves are reported by the president of the Karkar-Dudkash mines to be in excess of 9Mt, based on the 1938 survey. The productivity of the mines is low, but it could be increased. The mining operations would need a complete upgrade to support the

Below - Figure 5: The packhouse at the Ghori I plant can package 4000 50kg bags in seven hours with a four-headed packer. The room is extremely dusty, posing a threat to employee health and the environment.

current operations of Ghori I and the much larger requirements of the Ghori II and Ghori III plants.

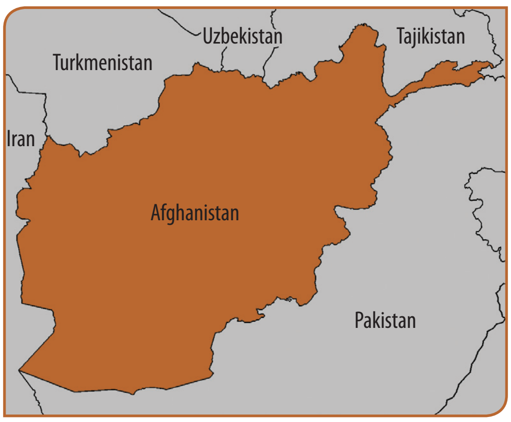
Coal is delivered in uncovered 12t trucks and conveyed to the open storage hall using a bridge crane. It is ground into a fine powder in two 3t/hr capacity ball mills before being fed into the mill feed bins by table feeders. The ground coal is air swept from the mills through a rudimentary separator to an intermediate storage bin, with the oversized particles returning to the mill to be reground with new mill stock. It is then metered from an intermediate bin through a twin-screw feeder to the coal delivery fan, which is also the mill system fan. The pulverised coal is transported to the kiln burner for combustion.

The coal is not homogenised in any manner prior to entering the mill, although blending in the storage hall would result in a more consistent heating value of the coal. There is no instrumentation to determine the product load in the mill and no indication of process control for pulverised coal fineness.

The thermal energy value of the coal is 5500Kcal/kg. Its sulphur content ranges from 1.5-4.0%, while the ash content averages 25%. All of the ash is consumed in the clinkerisation process. Assuming that it requires 1400kCal/kg clinker, the manufacturing process requires 250t of coal to produce 1t of clinker or, at the current production rate, approximately 4050t/yr of coal.

No alternative fuels are used at the Ghori I plant and none will be used at Ghori II once it is complete, as the old wet-process kilns were not designed to burn anything other than coal. However, the Ghori III plant, which will have a modern dry-process kiln, may have alternative fuel burning facilities. It will be built to the highest sustainable environmental, health, safety and social standards.

Ghori I receives electrical power from a hydroelectric plant located along the Pol-e-Khomri River, some 3km north of the plant. The hydroelectric plant reportedly provides a dedicated 3MW supply of electricity to the Ghori I plant during the 9.5 months of the year when hydroelectric power is available, in spring-autumn. The plant has a diesel generator to support limited production during the winter and for use during power failures or emergencies.



Emissions and regulations

The Government of Afghanistan's Ministry of Irrigation, Water Resources and Environment (MIWRE) has jurisdiction of environmental issues at the federal level. However, with regard to emissions, there are very few controls in place at the Ghori I plant. Jutson said that the limestone/clay mix would be expected to absorb much of the SO_x generated in the kiln, therefore SO_x emissions would be expected to be low. CO_2 emissions are estimated at 0.56t for every 1t of clinker produced.

Dust-laden gasses are pulled through the kiln by an induced draft (ID) fan and exit to the atmosphere through a concrete stack. There is no collection of particulate matter between the kiln and the atmosphere. It has been estimated that 20% of the partially-processed kiln feed is lost to the atmosphere. Based on an average production rate of 90t/day at 180 days of operation annually, this equates to 3240t/yr of dust lost to the atmosphere. This is not only an environmental matter, but it evidences poor plant efficiency, as some 65% of the energy required for clinkering has already been imparted to this fugitive dust. Both ID fans are in poor repair due to the heavy dust load and need replacement. Installation of a mechanical filtering device could capture 90-95% of the particulate matter currently exiting the stack.

However, there are no planned changes to the Ghori I plant's environmental control systems and no intention to install emissions reductions technologies or energy-saving equipment.

Market and distribution

Cement production in Afghanistan was developed by the state at the following three sites:

- Jabal Saraj, Parwan Province (1958): 75km north of Kabul, the Czech plant was designed as a single-kiln, wet-process plant with a clinker production capacity of 100t/day or 33,000t/yr. However, less than 500,000t of limestone is available at its mine and that which is available is low-quality, with high Fe_2O_3 content. The plant was shut down by the Taliban in 1996 and has remained dormant since then. Estimates of its total lifetime production is a mere 100,000t.
- Herat Province (1978, unfinished): The 300,000t/yr wet-process plant was only ever 50% erected. Less than 400,000t of limestone is available at the site.
- Pol-e-Khomri, Baghlan Province: The Ghori site is described herein.

According to Jutson, domestic cement demand has been projected to exceed 5-6Mt/yr or 150-200kg/person/yr. The demand is currently met by imports from neighbouring countries at prices set by foreign suppliers and transport operators. Decades of Soviet occupation, Taliban incursion, civil war and civil insurrection have favoured imports.

The Afghan cement sector is a natural market for producers in Pakistan and Iran, as well as their Afghan distributors. More than 98% of Afghan domestic cement consumption is imported from Pakistan (85.7%) and Iran (12.8%), in 50kg bags. This is reflected in the estimated average regional price of about US$116/t in 2012, driven substantially by the transportation cost for imports from Pakistan.

Imports from Pakistan to Kabul are usually supplied by Bestway, Cherat, Kohat Cement, Foji and Lucky Cement. The journey is 300-500km, typically a one day trip by truck. Bestway and Cherat are the two largest suppliers of cement and together comprise a 70% share of the total imports from Pakistan. Imports from Iran to the eastern regions of Afghanistan, such as Herat, also come via truck, as again, it is a 300-500km trip that can be achieved in a single day. The vast majority of imported cement enters through three Afghan border towns, as detailed below and ranked by declining import volumes:

- Torkham, Nangahar Province in northeast Afghanistan: Facilitates the highest volume of imports due to its location within the Khyber Pakhtunkhwa, where many Pakistan cement plants are located;
- Spin Boldak, Kandahar Province in the southeast of region of Afghanistan;
- Islam Qala, Herat Province in the west part of Afghanistan: The region facilitates Iranian imports due to its proximity to the Iranian border.

All of the importers are believed to use dry-process cement plants. Importers, who are allied with local distributors and customs officials, naturally resist new Afghan cement plants, such as the Ghori III plant, which would increase competition. The Afghan cement market is overtly affected by the political landscape. Volatile demand and a capricious regulatory environment discourage capital projects.

Outlook

Speculating on the present and future of the Ghori site, Juston said that it is business as usual. "Keep calm and carry on," was his phrase. The Ghori I plant faces many challenges, including fuel supplies, an uncertain market and competition from importers.

The reason that there are no upgrade plans for the Ghori I and II plants, aside from the completion of the Ghori II plant, is that when Ghori III is finally completed, the outdated Ghori I and II plants will likely prove uneconomic in terms of production costs and will ultimately be closed. With regards to the Ghori III plant, Jutson anticipates that the tender process will be reinstituted once the new government is established and the MoM resumes its charge. Despite the market competition, he asserts that there is plenty of room for the Ghori III plant, with its 1-2Mt/yr of cement production, without producing a threat to existing importers or their domestic distributors.

As far as the Ghori cement plant owner, AIC, is concerned, there are no plans to invest in new plants in the foreseeable future or to add to the Ghori cement plants' existing product range.

Speculating on the future of the Afghan cement industry, Jutson said that transparency in regulation, licensing, production and distribution would go a long way to supporting the operations of the Ghori III cement plant, for the benefit of all Afghans.

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	Afghanistan Ghori I cement	Portland cement standards				
		Pakistan	Iran			USA
		PSS 232-1983(R)	325 T1	425 T1	525 T1	ASTM C150-99
Blaine (cm^2/g)	3670	2800-3000	2800	2800	2800	2800
No 325 sieve (% passing)	62.5	-	-	-	-	-
Expansion (mm/%)	-	≤10mm	0.8%	0.8%	0.8%	0.8%
Compressive strength after 1 day (kg/cm^2)	-	-	-	≥100	≥200	-
Compressive strength after 3 days (kg/cm^2)	95	≥155	≥120	-	-	≥120
Compressive strength after 7 days (kg/cm^2)	136	≥240	≥200	-	-	≥190
Compressive strength after 28 days (kg/cm^2)	189	≥352	≥325	≥425	≥525	-
Loss on ignition (%)	5	≤4	≤3	≤3	≤3	≤3
MgO (%)	1.2	≤4	≤5	≤5	≤5	≤6
SO_3 (%)	2.3	≤3	≤3	≤3	≤3	≤3.5
Iron ratio (IR)	0.32	≤1.5	≤0.75	≤0.75	≤0.75	-
Lime saturation factor (LSF - %)	-	0.66-1.02	-	-	-	-

Left - Table 1: The cement standards of Pakistan, Iran and the USA, compared with the analysis of cement produced at the Ghori I plant.