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By Markus Akermann, CEO of Holcim Ltd and Chairman of the Holcim Foundation for Sustainable Construction
After eighteen months of engineering and two years of construction, the Holcim Apasco Hermosillo cement plant was officially opened on March 10, 2011. Located in the state of Sonora in northwest Mexico, it is Holcim Apasco’s seventh plant in the country. The greenfield plant cost USD 400 million to build and is designed to produce 1.6 million tonnes of high-quality cement annually, expanding Apasco’s production capacity to some 12 million tonnes per year.

The Hermosillo plant operates with state-of-the-art production processes, equipment, and control systems, and it meets high standards for safety, quality, energy efficiency, and environmental performance. But that, of course, can be said of any new Holcim plant, so why does Hermosillo deserve to be the subject of this book? The plant is extraordinary for two main reasons. First, the administration and service buildings – all the habitable buildings on the site – were designed to meet the stringent sustainability criteria defined by the Holcim Foundation for Sustainable Construction. These criteria call for balanced environmental, social, and economic performance, contextual appropriateness, and innovative and exemplary advancement in construction.

Hermosillo is the first cement plant in which all buildings aspire to such high standards, but it is neither the first nor the last time that Holcim shall build green buildings at its plants. The precursor is the Holcim Costa Rica
administrative building in San José, built in 2004 as a model of sustainable construction. Holcim Indonesia is designing a green administration building for its new Tuban cement plant, and Holcim Brazil is also focusing on sustainability already during the planning phase for its new Barroso plant in Minas Gerais. These examples show that Holcim not only promotes sustainable development, but also practices what it advocates.

The second thing that makes Hermosillo extraordinary is the production plant itself, which sets new benchmarks for safety design and environmental performance, as well as throughout the design, procurement, construction, and testing phases of its commissioning. Incorporating several technical innovations and many forward-looking design features, the plant is poised for a long future, proving that sustainable construction is feasible even in an industrial context and in a harsh desert climate. Hermosillo is a call for rethinking and a model for change.

This publication documents many facets of the Hermosillo plant – the latest milestone on Holcim’s journey toward sustainable development. Thousands of people outside and inside of Holcim were involved in this project. They collaborated to translate Holcim’s sustainable values into reality. Their dedication is evidence of Holcim’s technical competence and social and environmental responsibility, true to Holcim’s vision of building foundations for society’s future. This book is dedicated to all of them.
“Target issues” for sustainable construction

- Innovation and transferability
- Ethical standards and social equity
- Environmental quality and resource efficiency
- Economic performance and compatibility
- Contextual and aesthetic impact
Sustainable development and architecture are multifarious subjects intertwined with many other complex issues. To make sustainable construction easier to understand, assess, and practice, the Holcim Foundation for Sustainable Construction developed a five-point definition. These five so-called “target issues” serve to measure the degree to which a building contributes to sustainable development.

Three of the five “target issues” align with the primary goals of the Rio Agenda: balanced environmental, social, and economic performance. A further “target issue” applies specifically to building – the creation of appropriate buildings, neighborhoods, towns, and cities. The final target issue recognizes the need for significant advancements that can be applied on a broad scale.

These five “target issues” are explained in detail and illustrated at www.holcimfoundation.org/target. The pages that follow summarize the five criteria and how the Holcim Apasco Hermosillo cement plant meets them.
Innovation and transferability
Significant improvements in the construction and use of buildings of all types must be applied on a broad scale to achieve global sustainability. Practices and ideas that transfer best are those that are affordable, simple, and broadly applicable.

The Holcim Apasco Hermosillo cement plant is a pioneering achievement for the cement industry. It is Holcim’s first factory in which all the habitable buildings are designed to meet the Holcim Foundation’s criteria for sustainable construction.

The Hermosillo facility sets a new benchmark for cement plants in terms of safety design, cost efficiency, future adaptability, energy and water efficiency, sustainable design of all buildings, environmental sensitivity, and incorporation of innovative technologies.

The project makes a significant step toward sustainable development of industry by giving environmental and social concerns equal weight as economic ones. During the design and construction phase, extensive resources were voluntarily invested in environmental protection and safety engineering.

The intense heat of the desert sun is ingeniously harnessed to drive a high-efficiency zero-carbon air conditioning system for the main building. This installation is the first commercial solar-driven absorption chiller system in Latin America.

The 200 kW photovoltaic system is the largest such commercial installation in Mexico. It sets a prominent example of use of solar energy in Mexico, a country that is ideally situated to exploit this locally neglected technology.
Ethical standards and social equity
The built environment greatly influences quality of life and healthy social interaction. Sustainable construction requires fair and respectful treatment of everyone affected during the design, construction, use, and recycling of buildings and infrastructure.

Although fundamentally an industrial plant, Hermosillo was designed with people in mind. The manifest respect for people and for nature has inspired a working environment that employees are proud of and where people are satisfied to work daily.

Hermosillo is one of Holcim’s safest cement plants. Three million additional dollars were invested to improve mechanical access and ensure safety, exceeding national and international safety requirements.

The Hermosillo buildings are designed to provide a comfortable, healthy, and open working environment that promotes social coherence, teamwork, and interaction among managers and technicians in all areas of administration, research, quality control, and service.

During the construction phase the design team collaborated with users and with the contractors to develop a shared vision for the project. A well-furnished trailer park was set up on site to provide an agreeable temporary working environment and foster team spirit.

The main building offers a range of amenities to support employee well-being: ergonomic furniture, natural lighting, generous open spaces, good meeting rooms, a cafeteria serving three meals a day, a medical station with doctor on duty, a fitness center, and others.
Environmental quality and resource efficiency
The way we build must preserve the planet, respecting land, air, water, and ecosystems as life-supporting resources. Buildings must spare finite resources, avoid carbon emissions, reduce waste, control pollution, and provide environments that are healthful for all forms of life.

The energy-efficient low-carbon buildings of the Hermosillo plant minimize environmental impact by using water-conserving technologies, locally sourced recyclable materials, passive cooling and daylighting, and appropriate alternative mechanical and electrical systems.

Plants and animals on the site were protected during construction. 66 fauna specimens and 960 flora specimens were rescued, documented, and safely relocated. 265 hectares of disturbed land beyond the grounds was repaired to enhance the natural habitat.

The facility meets the strictest national and international standards for environmental performance, specifically energy consumption and monitoring and control of emissions. Specific thermal energy consumption of production measures 3,070 kJ/kg clinker, a best-in-class figure.

The plant sets a new benchmark for water conservation. By circulating cooling water, using air-to-air heat exchangers instead of air-to-water, and employing other measures, specific water consumption for processing is held to 0.2 m³/t clinker, the lowest figure in the Group.

The main building incorporates progressive green technologies such as the photovoltaic system which meets the building’s electricity needs, a solar-driven absorption chiller, and innovative daylight ducts for naturally illuminating interior spaces.
Economic performance and compatibility
Buildings must be financially feasible to build, operate, maintain, adapt, and ultimately remove. They should support sustainable economic mechanisms, activities, and purposes. Construction projects can stimulate economies, lead to economic integration, establish long-term livelihoods, and equitably distribute wealth.

The Hermosillo cement plant is strategically located in economically important northwest Mexico, complementing Holcim Apasco’s geographic coverage. The plant is situated to flexibly serve parts of the US market and Central and South American markets in the future as demand may dictate, and is thus a secure long-term investment.

Incorporating the latest technology to minimize electrical and thermal energy consumption, the plant shows outstanding operational efficiency and economic performance. Specific clinker cost is among the lowest in the Group.

The plant is laid out for the economical addition of a second line at any time without disrupting production. From quarry to dispatch, everything necessary is sized for double capacity. The extra cost of oversizing today is a well-considered investment in the future.

The cement plant was built within budget, and commissioning was meticulously conducted. The investment paid off: Startup was one of the smoothest on record, with operational targets being achieved within 24 hours.

The plant equipment and buildings incorporate high-quality and durable materials for a long useful lifespan. All structures are designed to require low maintenance and to be economically adapted to meet changing requirements over time.
Contextual and aesthetic impact
Sustainable architecture is durable and adaptable. It provides attractive, comfortable, and functional environments. It enhances its surroundings, fitting functionally and aesthetically into its setting, providing culturally valuable indoor and outdoor spaces.

The buildings of the Hermosillo plant are an appropriate aesthetic, cultural, and physical response to the desert setting, with simple building forms, natural colors, passive and active cooling strategies, and landscaping with indigenous flora.

Engineered for utility, economy, and environmental performance, the plant displays technical competence and industry leadership, creating a local landmark and global reference for Holcim and expressing the Group’s identity, values, and responsible citizenship.

The project improved the surroundings of the plant by rehabilitating disturbed desert land, using local soil and native plants, and creating drinking ponds. This work was done in coordination with the authorities.

An architect was hired to design the six buildings at the plant. The layout and architectural language creates a visually and spatially cohesive complex of high quality, seldom seen at industrial sites, especially remote ones.

The plant is situated and laid out for efficient material flows and economy to functionally fit its surroundings. The site was selected for its mineral reserves and to make use of an available rail line, which was extended to the plant.
Holcim Apasco in Hermosillo
Hermosillo is Holcim Apasco’s seventh cement plant in the important growth market Mexico. The company operates five plants in the states Colima, Guerrero, Mexico, Tabasco, and Vera Cruz, serving the southern part of the country. A further plant in Coahuila serves the north central region. The new Hermosillo plant in the state of Sonora improves Holcim’s geographic coverage of Mexico. It efficiently serves the northwest market, which had previously been served by road and sea from the distant Tecomán plant in Colima.

Holcim Apasco’s coverage of Mexico is completed by 23 distribution centers, 141 ready-mix concrete plants, and two maritime terminals, at Manzanillo and Guaymas.

Sonora is Mexico’s second-largest state, covering 179,500 km². It is named for the expansive Sonora Desert, a third of which extends into the United States. Hermosillo, the capital of Sonora, with a population of 785,000 is the 20⁰ largest city in Mexico. The municipality encompasses more than 3,800 communities and reaches to the Gulf of California. Besides the Hermosillo plant, within Sonora Holcim Apasco operates a maritime
terminal at Guaymas, a distribution center at Hermosillo, and two ready-mix concrete plants, at Hermosillo and at Puerto Peñasco.

As a well-connected city and growing economic center of northwest Mexico, Hermosillo was a natural location for the new plant. The city is home to nearly all of the state’s manufacturing, including automotive, electronics, and IT products. Other local industries include mining, food processing, textiles, wood products, printing, chemicals, petroleum products, and plastics. Hermosillo enjoys strong economic ties to the southwest United States, locally referred to as Sonora North. From Hermosillo, Mexican Federal Highway 15 runs northward to the US border, 280 kilometers away, and southward to the port of Guaymas, 130 kilometers away on the Gulf of California. Sonora State Highway 100 runs westward to Bahai de Kino, 100 kilometers away on the Gulf of California. Sonora State Highway 20 runs to the east, to the plant. A Ferromex (Mexico’s national railway) mainline heads north from Hermosillo to the US border and south to Guaymas and beyond. The line can be used to carry cement, raw materials such as gypsum and fluorite, and fuels such as petcoke and coal.
A suitable site for the new plant was found 23 kilometers east of Hermosillo. The isolated desert site holds ample limestone and basalt reserves. Formerly part of a large cattle range, the 3,000-hectare parcel had to be purchased in its entirety, thus Hermosillo is one of Holcim's largest sites, encompassing 30 square kilometers (7,400 acres or 11.5 square miles) – half the size of Manhattan Island. Sonora State Highway 20 runs through the parcel. A branch rail line was extended to connect the plant to the freight yard at Hermosillo and to the Ferromex national network. The terrain at the developed part of the parcel is virtually flat. The subsoil is homogeneous with good bearing capacity, ranging from 25 and 60 t/m², depending on geometry and depth of the foundation. Foundation pilings are unnecessary. The site is some 200 kilometers from the San Andreas Fault and is classified in Seismic Zone 3 of the Uniform Building Code.

At 29°04' North latitude and an altitude of about 282 meters above sea level, the site is exposed to extreme solar radiation, which peaks at 10,020 watts per square meter in August. Cloudy days average 33 per year. The
annual average temperature is 32°C. The climate in summer is extremely hot; in August the average maximum temperature is 45°C, and peaks can exceed 50°C. Winters are moderate; in January, the coldest month, the average maximum temperature is 16.6°C, the average minimum temperature 8.9°C, and the minimum minus 3°C. Relative humidity ranges from 38% to 79%, averaging 49%. Rainfall averages 353 millimeters per year. Most rain falls in evenings in July and August, often in heavy showers that can dump up to 70 mm in an hour. Atmospheric pressure is maximum 1,000 mbar, minimum 979 mbar, and the annual average is 983 mbar. Prevailing winds are generally mild and come from the south-southwest. Hurricanes can occur.

No public water utilities serve the site. A pond has long been on the parcel, but no surface aquifers. An underground river flows 35 meters beneath the ground surface. No zoning restrictions apply to the parcel, but archaeological restrictions do apply. Archaeological relics were known to be on the site before the project began.
Site design

A rectangular area of roughly 200 hectares at the western edge of the parcel was selected for development of the plant. The chosen plot is adjacent to State Highway 20, near a large gravel deposit, and at the point closest to the branch rail line to Hermosillo. As a greenfield site – or, literally, a tan desert site – the land offered virtually unrestricted planning freedom. With a practically flat topographic base map, homogenous terrain and subsoil, and absence of any previous construction, the engineers were free to lay out the new plant for optimal operation, unencumbered by complications and restraints encountered in expansion projects. The plant was planned for initial development in a single phase. The broad design strategy was to facilitate efficient and economical industrial production, control access, and ensure safety and comfort, while controlling and reducing the environmental impact of construction and operations.

The plant layout translates the functional relationships and processes of cement production directly into a spatial arrangement of equipment and buildings, engineered for efficient transport of materials and circulation of vehicles and people. The general functional zones of cement production are material delivery, material storage, manufacturing, and packing and shipping. Administration and support represents a further zone.

The line of processing equipment is formed into a U-shape that wraps around the administrative and support buildings. These buildings are organized along a north-south circulation axis, with the plant entrance at the south and the main office at the north. Thus passenger and pedestrian traffic are well separated from material transport on the site. The site is fenced in, and a guardhouse controls access at the entrance to ensure safety and security on the grounds. Ample shaded parking spaces for cars and bicycles are provided near or beneath the buildings. The site plan is
laid out in anticipation of future expansion of the plant. A second line can be cost-effectively inserted at any time, without disrupting operation of the original line, and without requiring replacement, upgrading, or expansion of any of the equipment or facilities – from the quarry to dispatching.

The plant is powered by the public grid. 115 kV, 60 Hz power is supplied via a new overhead transmission line connected to a new main electrical substation owned by Holcim Apasco.

The plant has an emergency diesel generator to supply essential power consumers in case of a power failure. A large on-site photovoltaic system generates power for the main building.

Water is supplied by a well that taps the underground river. A second well is installed as a backup. Sewage is treated on site. Concrete-lined stormwater channels control surface water on the site. Swales beyond the grounds divert floodwater from flowing into the plant.
Tendering

Tendering, or obtaining bids for the construction and erection of the new plant, was performed in 2007, using a limited number of large packages and a semi-turnkey contracting approach. The proposed execution method consisted of a large supply-and-services contract for equipment (mechanical and electrical), engineering (process, mechanical, electrical, and process control and automation), and erection and commissioning supervision assistance of the equipment suppliers.

Main global manufacturers were invited to tender. Tender evaluation was driven by the target to optimize the project total installed cost without compromising safety, environmental performance, cement product specifications, production capacity, production cost, or the project schedule to first cement and first clinker.

Mechanical, electrical, and control equipment was supplied on a semi-turnkey basis by Fives FCB (France) as main original equipment manufacturer also in charge of the design, engineering, and supply of steel structure and plate work. This company was selected considering not only technical requirements and cost targets, but also the supplier’s capacity to constructively collaborate in a partnership approach to project execution.
Construction

Construction began December 2007 and ended July 2010. 238 companies worked on the project, and up to 675 people were on the site at any one time. Accumulated man hours throughout the construction phase totaled over 9 million, and turnover was 13,800. With normal turnover, accumulated man hours would have been around four million. Turnover was very high because of the extreme climate, the proximity to the US border, and the under-skilled workforce.

A ready-mix concrete plant was set up on the site for the construction phase. The first thing built was a concrete access road to accommodate vehicles, control accessibility, control dust, and prevent erosion. A “village” of containers housing temporary offices and equipment was set up on the future plant grounds. A babbling water fountain was placed at the center, and wooden walkways were laid within the village. For additional comfort of the contractors and team members, extra-wide containers were acquired and furnished with high-quality furniture that ultimately went into the finished buildings. This attention to comfort, wellbeing, and promoting teamwork characterizes the project from beginning to end.

Construction was successfully completed within budget and on schedule, although it was the most challenging phase of the project due to the local conditions – and not only the temperature. The best available local contractors were hired, but most of them lacked suitably skilled personnel and the necessary equipment for construction and erection of a cement plant. Some contractors sought quick profit at the cost of quality; others suffered from poor management and supervision. Two contractors went bankrupt before finishing their contracts. Many lacked safety awareness.
Safety is a priority at Holcim, and zero harm to people is a corporate mantra. The construction project was strictly managed to promote and enforce safety. Holcim’s safety directives and guidelines were enforced with rigor but also with an emphasis on fairness and open communication.

Every worker who entered the site received appropriate safety training, which totaled over 90,000 hours of safety training. Over 23,000 safety inspections were conducted during the construction and erection phase. 8,376 work-safety analyses were conducted. 4,194 alcohol and drug tests were given, and more than 290 people fired due to noncompliance with Cardinal Rule No. 4, which prohibits substance abuse. 344 recognitions for following Cardinal Rules were awarded, and 1,129 zero-tolerance sanctions were given.

In spite of the extensive safety efforts, one fatality did occur. A construction worker was electrocuted when a vehicle arm contacted an overhead power line. 22 other accidents were reported, none of which involved major injury. All incidents were thoroughly investigated and appropriate actions taken. Lost-time injury frequency rate (LTIFR) was less than 2, and lost-time injury severity rate (LTISR) was less than 60.
Commissioning a cement plant is the process of transferring the plant from the team that built it to the team that will run it. This process consists of several stages conducted over many months. It starts with safety, mechanical, and electrical inspections and tests at the completion of erection. There follows dry-run tests of the equipment and processing sequences, also known as “dry commissioning” or “cold commissioning,” and system verification tests using material, also known as “hot commissioning.” This stage includes plant optimization, trial operation under normal operating conditions, and performance tests. Experience shows that four to six months are typically required in order to correct problems and optimize the equipment to achieve target OEE (overall equipment effectiveness). Commissioning ends with provisional takeover of the plant. Commissioning at Hermosillo began April 2010, five months behind schedule, and ended March 2011. The first clinker was produced six weeks later than originally scheduled. In spite of this, the commissioning of Hermosillo is considered one of the best in the history of Holcim.

At startup, every piece of main equipment ran flawlessly and met or exceeded the guaranteed performance levels for output, capacity, energy consumption, and all other specified ratings. It was not necessary to stop and restart the line even once. On-spec clinker was being produced within 24 hours, and target OEE was achieved within 24 hours. There was essentially no performance curve to plot – performance started at the level of best demonstrated practice (BDP) and remained there. Accumulated kiln net OEE through July 2011 was 93.6 and net kiln availability 98 percent.

Commissioning at Hermosillo followed the usual process. What was unusual was the way the transfer from the project team to operating team was organized. Once the construction team had finished with erection, a large team of qualified maintenance and operation personnel was called in to
thoroughly check everything. The commissioning team included members from the Holcim Apasco Hermosillo plant team and support personnel from other Holcim Apasco plants (11 mechanical technicians, 18 electrical technicians, 7 process technicians, 5 quality control technicians), Holcim Group Support (1 commissioning manger, 8 consultants), FCB (1 commissioning manager, 2 mechanical technicians, 2 electrical and instrumentation technicians), ICER (5 control system engineers), and personnel from 40 suppliers and subcontractors, including Ingersoll, BKG, Atmos, Metso, Tecman, Thermo Fisher, Sthim, DiMISA, Bedeschi, Dosatec, Rexnord, Aumund, CPT, Flaktwood, Pfeiffer, Yara, Redecam, Schenck, Martin Engineering, Pfaff, Fives Pillard, Flender, IKN, Fives Solios / Cammsa, ATS, Facchini, Ventomatic, Vidmar, Kone Cranes, Alimak, ABB, AREVA, Rockwell, SDMO, ABB, Sick, Thermotecnik, HGHermostillo, Siemens, and Dalog.

Maintenance experts know exactly where to look for problems. They checked all equipment, first piece by piece, and then in sequence. Electrical controls are a typical source of problems in commissioning. Every machine is wired to the electrical room and to the control panel – some 25,000 connections for a typical plant. Each of these connections must be checked. Experience shows that typically 10 to 15 percent will be wrongly connected. Every one of these must be found and corrected for smooth commissioning.

The team of 70 mechanical specialists, electrical specialists, and experts for kilns and mills stayed on site up to six months to prepare for startup. The project management gave the team ample time to completely ensure the quality of the installation. The temptation can be great for project managers to rush commissioning in order to “stay on schedule” and “keep within budget,” but this always proves to be false economy. Good commissioning requires time, but ultimately saves even more time.
Inauguration

The plant was inaugurated March 10, 2011. The ceremony was attended by Holcim CEO Markus Akermann, Holcim top regional management, Holcim Apasco top management, many local and national government officials and legislators, industry representatives, leading business figures, customers, distributors, contractors, employees, and local neighbors. By far the most prominent guest was President of Mexico Felipe Calderón Hinojosa, whose attendance attests not only to Holcim’s respected standing in Mexico but also to the significance of the new Hermosillo plant. “It’s an extremely important facility that – it’s clear after touring it – is probably the world’s most modern and, if not the most modern, one of the most,” said Calderón at the inaugural ceremony. He added that the new plant incorporates cutting-edge technology and was designed to be sustainable and have limited environmental impact.

Holcim CEO Markus Akermann in his address recalled that Holcim had announced plans to invest in the plant three years earlier and had stayed true to that commitment despite the global recession: “With this plant, Holcim Apasco strengthens its competitive position and leadership in the country, particularly in the northwest Mexico region,” he said. “This plant shows the importance of Mexico to Holcim, and our confidence in its future. Holcim Apasco, as a socially responsible company producing high-quality products for its customers, will continue to play its part in a prosperous, competitive, and strong Mexico.”
Cement production facility

By Pedro Lluch, Project Manager Hermosillo plant
The production facility incorporates the latest highly efficient technology, including a 6-stage preheater with low-pressure drop cyclones and low-NOx precalciner, one 4.5 meter by 70 meter rotary kiln, three Horomill 3800 mills for cement grinding, five crushers for raw materials, correctives, and additives, and a very flexible cement loading and dispatch system with a 16-spout packing machine and bag sealing system. All equipment was specified to handle dry and highly abrasive raw materials and withstand extreme desert temperatures that can exceed 50°C in summer. The master plan is conceived for two kiln lines, the second line to be built in the future. From the primary crusher to raw material grinding, and including packing and dispatch, the substation, electrical rooms and system, and the spaces and facilities in the buildings, everything is sized for twice the present capacity.

Water is a precious resource, especially in the desert. The entire Hermosillo plant is designed to require a minimum of water. Process water for cooling
is by far the greatest water requirement in cement production, and the plant incorporates two main strategies to minimize it: cooling water is circulated in a closed-loop system and air-to-air heat exchangers are used instead of air to water. Specific water consumption for processing is 0.2 m³/t clinker – half the consumption rate of the Ramos Aripe plant, which previously had the lowest rate in the Group.

Exhaust emissions at the plant are rigorously controlled and monitored. For each type of contaminant, the most stringent standard was adopted: either the national standard, European standard, or Holcim standard. Dust control is comprehensive. Solid fuels, raw materials, additives, and correctives are stored in enclosed halls. Only tire chips are stockpiled outdoors, because they present a potential fire hazard but not a dust problem. All belt conveyors are covered. All plant roads and walks are paved. More than 84 nuisance filters and dust collectors are installed throughout the plant, exceeding the standard requirements.
Focus on safety

Typically, when an industrial plant is being designed, the engineers concentrate on production efficiency and low cost – and not safety first. The designers assume that mechanics will use ladders, cranes, vehicles, and scaffolding to reach the equipment for maintenance or repairs. Problem is, using these temporary forms of access while working is dangerous.

From the first moment, the Hermosillo plant was designed with safety in mind – including safe maintenance. Stairs are installed in place of ladders. Platforms are installed for good access and plenty of room to work. All critical points are easy to access. Of course guardrails are everywhere, painted hazard yellow. In fact, yellow is one of the four prominent colors of the plant.

A key step in the design process was a special safety review in which a safety specialist scrutinized all the drawings specifically for safe design of all equipment. This comprehensive review lasted throughout the detail engineering phase. The plant invested an extra USD three million in safety installations, exceeding by far the minimum requirements, and aiming to be one of the safest cement plants in the world.

For a heightened factor of safety, all buildings and structures on the site are designed for Seismic Zone 4 instead of Seismic Zone 3 and for hurricane winds up to 157 kph at 10 meters above ground.
Limestone and basalt are extracted, crushed, and blended in the quarries on the site. Given the abrasiveness of the local raw materials, a three-stage crushing system was selected to prepare the material for ball mill grinding. A crossbelt analyzer (PGNAA) ensures proper proportions of the material coming out from the primary gyratory crusher (1,450 tonnes/hour), while a single overland belt conveyor transports this raw material mix over a distance of 4.7 kilometers to the secondary cone crusher, which together with the corresponding screening system also delivers 1,450 tonnes/hour. After the addition of correctives, the third and final crushing step is achieved with a screen and a cone crusher.

The raw material mix is preblended and stored in an enclosed longitudinal chevron-type storage building, with a capacity of 50,000 tonnes, controlled by the PGNAA located after the primary crusher.

Grain size of iron ore, alumina, and other components for the raw meal is reduced below 70 mm by an impact crusher, and the material is stored in an enclosed longitudinal storage building in separate stockpiles (15,000 tonne total capacity), which allows simultaneous stacking and reclaiming.
Raw mix, correctives, and other components are conveyed to a set of five bins with a total capacity of 650 tonnes. The mix is controlled by weigh-feeders and an additional PGNAA before entering the tertiary cone crusher. The tertiary crusher prepares the material to maximum 19 mm (¾ inches) before being transported to the ball mill.

The ball mill equipment for the raw grinding operation was selected to suit the high abrasiveness of the raw mixes. The main characteristics of the shoe-bearing ball mill are as follows:

<table>
<thead>
<tr>
<th>Ball diameter / length: 4.8 m x 14.75 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fineness of produced raw meal: 15% residue on 90 µm sieve</td>
</tr>
<tr>
<td>Nominal capacity: 272 tonnes/hour</td>
</tr>
<tr>
<td>Main drive installed power: 4,900 kW</td>
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With the raw materials moisture being very low, no additional drying system is required. Raw materials are dried inside the raw mill using part of the hot gases from the clinker process. The remaining portion of the gases is mixed with the gases leaving the mill (at approximately 100°C) and the hot air coming from the clinker cooler. Two high-efficiency (> 95%) cyclonic separators of 4.6 meter diameter classify and collect the produced raw meal.

Dedusting of waste air from the kiln, raw mill, and clinker cooler is handled by a single bag filter. The system is designed to operate without conditioning, using the clinker cooler waste air to decrease the gas temperature for the main filter. Additional diluting air is utilized if necessary. The common filter assures minimal air dilution while providing additional stability for the dedusting system operation.
Clinker production

The 8,000-tonne raw meal homogenization silo is fed through a bucket elevator, which collects raw meal from the ball mill and dust from the main filter. From the blending silo, raw meal is transferred to a single-string 6-stage preheater with a low-NOx hotspot precalciner. The design of the precalciner burner, with a central channel of 400 mm, allows use of conventional fuels, alternative fuels (including solids), or a mix of fuels. Low levels of NOx emissions are achieved without an SNCR system or the use of reagents. Guarantee NOx emissions are 500 mg/Nm$^3$.

The three-pier kiln measures 4.5 meters in diameter by 70 meters in length. Rated clinker capacity is 3,500 tonnes per day. The kiln system includes girth-gear drive, self-aligning pinion, and a high-efficiency IKN clinker cooler. The kiln burner, with a channel of 100 mm for feeding alternative fuels, is specially designed to handle a range solid fuels, especially coal and petcoke. Tertiary air extraction is at the kiln hood. Refractory design follows the Holcim refractory concept.

An air-to-air heat exchanger cools the exhaust gas from the clinker cooler and controls the exhaust air temperature. The clinker cooler waste air is then directed to the main plant filter. Hermosillo is the only Holcim plant that has one common filter for the kiln and cooler instead of two main filters.
Fuels are all delivered by road and rail. Coal and pet coke are stockpiled in a storage hall with a capacity of 20,000 tonnes. Grinding is handled by a Pfeiffer vertical roller mill.

Tire chips are the only alternative fuel currently being used at Hermosillo. Currently, the budgeted thermal substitution rate (TSR) is 20 percent, although the kiln design allows up to 40 percent. The plant’s co-processing permit allows 7,000 tonnes per month. The plant owns a mobile chipper, which is used to chip tires in various cities of Sonora before the chips are trucked to the plant. The storage area holds 6,300 tonnes of chips. The use of waste tires as fuel preserves nonrenewable natural resources and reduces dumping in landfills.
Cement grinding

From the cooler, the clinker is conveyed to a 45,000-tonne silo or via a bypass to a 2,000-tonne silo for off-spec clinker. Two pan conveyors connect the main clinker silo to the cement grinding area.

Cement grinding additives, mainly gypsum, pozzolan, and limestone, are delivered by truck and processed by an impact crusher (maintaining grain size below 70 mm), stored in an enclosed 13,000-tonne hall which allows for simultaneous stacking and reclaiming. Additives are added before finish grinding.

Three independent and highly efficient Horomills (HRM 3800) grind the cement while independent belt conveyors, each individually feeding one of the mills, assure versatility of cement grinding mixes. A high level of cement fineness is achieved without the addition of water. Grinding rates range from 65 to 96 tph, depending on the cement type.

Although Horomill technology has been on the market for 20 years, only one other Horomill exists in the Holcim Group – at the Cartago plant in Costa Rica. Operators and maintenance personnel from Hermosillo were sent to Cartago to acquire the knowledge and experience necessary to work with the mills, which are trickier to operate than ball mills. With three of the latest-generation Horomills, the Hermosillo plant is gaining considerable experience with these machines, which offer some significant advantages regarding energy efficiency, flexibility, and versatility. This knowledge and experience can prove valuable at other Holcim plants.

Three types of cement are produced at Hermosillo: CPC40 cement, CPC-30R cement, and CPMM mortar cement, marketed as Mortero Maestro. The cements are stored in three 12,000-tonne silos.
Cement packing and shipping

The palletizing building is designed for storing pallets and for feeding rail wagons and trucks. The 16-spout bagging machine has a capacity of 3,600 bags/hour (180 t/h for 50-kg bags) and is fitted with an automatic bag-sealing system. The palletizer (180 t/h capacity) is also automatic, as are the feeding of cardboard onto pallets and the pallet-wrapping system. The loading unit for big bags (2-tonne bags) has a capacity of 40 t/h.
The three cement silos are equipped with a bulk loading system for trucks and railcars. Each loading unit, with a 300 t/h capacity, is designed to move on rails and fill an entire hopper without the requiring the train to move. 35 percent of the cement leaves the plant in bulk by train, 25 percent in bulk by truck, 30 percent in palletized 50-kg bags, and 10 percent in big bags.
Auxiliary buildings

By Daniel Wentz
Supporting the manufacturing operations are six habitable buildings on the Hermosillo grounds: the administration building, warehouse and workshops, sales and logistics building, truck drivers building, lockers and rest rooms for staff, and guardhouse.

The administration building is the main building on the site. With a total floor area of 5,400 m² it gathers many functions under one roof for efficient thermal performance and a minimum footprint. Besides offices and meeting rooms, the building houses the concrete and cement laboratory, cafeteria, dressing rooms, medical station, fitness room, garage, and mechanical and storage rooms.

The cement laboratory at Hermosillo features a complete array of state-of-the-art instrumentation, a spacious and ergonomic layout, and modern architectural design. The lab is physically divided into two parts, one for chemical analysis and the other for physical testing of concrete and cement.

The warehouse and workshop building is divided into four areas: main plant storage, maintenance workshop, lubricant storage, and outdoor storage. The 2,300 m² building also includes two small offices.
The staff lockers and rest rooms building measures 484 m² and also contains a cafeteria and kitchen.

The sales and logistics building is a contact facility for customers and sales management. This 224 m² building includes an office area and an inbound and an outbound weighbridge.

The truck drivers building accommodates third-party truck drivers who deliver or pick up materials from the plant. The 100 m² building gives drivers a place to clean up, relax, and eat before starting another long drive. Truck drivers are an important part of the business operation, and their needs are often ignored in the design of cement plants. At most cement plants in Mexico truck drivers take their breaks in the shade beneath their trucks.

The guardhouse, 37 m², houses staff who control access to the plant and provide security information to visitors. All vehicles entering the grounds are recorded and all visitors must sign in.
The six buildings are designed to provide efficient, attractive, comfortable, and healthful work environments. Thermal, hygrometric, luminal, acoustical, and indoor air-quality conditions determined the design and construction criteria. Hermetic building envelopes were selected to keep out dust, a constant presence in the desert, and noise, constantly emitted from the production machinery. A controlled ventilation and heating or air-conditioning system is installed in all buildings except for the warehouse, where air conditioning would be impractical.

The buildings are designed as energy-efficient green buildings with low environmental impact. They incorporate passive cooling strategies, use locally available materials, and incorporate daylighting, water-conservation systems, and innovative high-efficiency low-emission mechanical and electrical systems.

The buildings are designed to visually express their raison d’être and they share a uniform architectural language. With a base course of cast-in-place concrete and clad in cementitious panels, the building exteriors are a display of cement and concrete within in a setting of roads and walks paved in concrete. Walls are the color of the local sand, and the red trim echoes the rosy desert sunsets. This harmony of materials and colors is reinforced by a harmony of form. Drawing upon the local modern vernacular of simple volumes, the architecture aesthetically suits the desert and industrial contexts, and the ensemble is furthermore integrated into its desert setting by the landscaping, which is conceived as an extension of the surrounding nature onto the plant grounds.
Good landscaping beautifies the working environment of a cement plant, supports local ecosystems, provides natural habitat, helps to naturally improve the climate in and around buildings, and enhances the good image of the plant and the company. Landscaping should be economical to maintain, requiring little energy, little fertilizer, no poisons, and – especially in the desert – should require a minimum of water.

The landscaping at the Hermosillo plant meets all these requirements in a straightforward and elegant way. Artificially landscaped areas are limited to the immediate surroundings of the buildings and the areas along main walkways. Materials are limited to crushed rock and indigenous plants, both sourced locally. Two colors and sizes of crush rock are used, creating fields of color and texture as a setting for the plants, most of which are placed individually or in loose groups. The variety and contrast of forms, colors, and textures produces a pleasant and chromatic landscape that is altogether fitting to the plant and the desert environment. This restrained landscaping concept blends well with the non-landscaped parts of the site, the areas of the site with undisturbed vegetation, and the natural desert beyond.
Most of the plants were dug up from the site before construction began. Trees that had to be removed were carefully extracted with roots intact and replanted on the site. Groves of trees were left on the plant grounds wherever practicable, and roads routed around them.

The plants in the artificial beds are watered by an underground drip irrigation system that deposits the water at the roots, minimizing water loss by evaporation. The desert-adapted gardens require 60 percent less water than a conventionally designed garden would.

A special landscaped zone circles the administration building. The greened earth berm is designed to create a cooler microclimate, reduce the albedo around the building, and direct breezes upward onto the facade, thereby improving thermal comfort within the building. The solar protection and insulating mass of the earth also reduces temperatures in the bottom floor of the building, improving the efficiency of heating, ventilation, and air-conditioning equipment and all other electromechanical components located there, as well as moderating the temperature in the garage area beneath the building.
Nowhere in the world does the sun so completely influence the environment as in the desert. Intense solar radiation provides strong illumination, causes extreme temperatures, and causes rapid evaporation. And among deserts the Sonora is extreme – it is known among engineers as the “Saudi Arabia of solar radiation.” With 332 sunny days per year, Hermosillo is an ideal place to apply solar technologies both proven and new – and the plant does this in several ways. The buildings make full use of the sun as a dependable source of illumination and energy for power generation and cooling.

The first rule of survival in the desert is to beat the heat. This is especially important from March to September, the hottest months. The buildings are designed to provide comfortable indoor environments by employing three strategies: first, passive control of all forms of thermal gain, by means of solar orientation, shading, reflection, insulation, ventilation, isolation, reducing exposed surface area, and reducing the ambient temperature around the buildings; second, the use of thermal mass to moderate temperature peaks; and third, an ingenious air-conditioning system that is the first commercial system of its kind in Latin America. All three strategies work in concert, they are energy efficient, and they generate zero carbon emissions – providing both environmental and economic advantages.
The buildings at Hermosillo incorporate virtually every known design strategy for passive cooling. Because heat infiltration occurs through the building envelope, the surface area of most buildings has been minimized by using rather cubic than elongated forms. Five of the six buildings are laid out on an east-west axis for optimum solar control. Walls and roofs are well insulated. The thermal resistance of exterior walls is 7.44 m² °C/W (U = 0.13 W/m² °C). Walls and roofs are light colored to reflect rather than absorb solar rays. Dark paving around buildings is also avoided to reduce the heat-island effect.

Insulating low-emissivity glass was specified for all windows. Nearly all windows of the buildings are fully shaded by protruding metal surrounds. The roof and part of the south facade of the administration building are shaded by the rooftop array of solar concentrators. The emergency stairs outside the east and west walls of the building provide additional shading for those facades. Other roofs are effectively protected by rooftop photovoltaic panels. Several of the buildings feature roof overhangs to shade the facades. A deep wrap-around overhang shades all windows and walls as well as the users and vehicles outside the sales and logistics building.
The warehouse and workshop building is the second-largest building on the site. It is not air conditioned but the indoor temperature is reduced by means of ventilated facades. The walls consist of a steel structure clad with cementitious panels on the exterior and gypsum board on the interior. As the air in the cavity between the panels warms, it rises through the cavity to the high ceiling, where it is expelled through a roof vent. The stack effect uses no energy and it reduces the indoor temperature by several degrees. The indoor comfort is better than in comparable non-air-conditioned structures.

The passive cooling strategies function very well, but of course only to a certain degree. On the hottest days, as the indoor air temperature inevitably rises above the temperature of the building itself, thermal mass comes into play. The massive concrete of the floors and walls begins to absorb the heat from the air, effectively moderating indoor temperature peaks. This cooling mechanism operates with zero energy. The combined array of passive cooling mechanisms greatly reduces the cooling load on the buildings, allowing the mechanical air-conditioning systems to be downsized.
It sounds impossible, but the scorching heat of the desert sun is used to cool the main building. The air-conditioning system is essentially driven by water heated by solar concentrators. The only power required is for three circulation pumps (two 7 hp and one 3 hp) and for fans to distribute the conditioned air within the building. A single-effect absorption chiller in the basement is fed with coolant (water and lithium bromide) heated close to boiling by 170 rooftop parabolic concentrators. The chiller produces cool water used to cool air that is then distributed via ducts throughout the building. Requiring solar energy, the system typically suffices to cool the building from 7:30 a.m. to 5 p.m. in the summer.

Absorption chiller technology is well proven, and a large range of chillers is commercially available. The expected service life of the chiller is easily fifty
years or more. The innovation here is combining the chiller with solar concentrators, which is highly efficient in the desert. Local adoption of this green technology is unfortunately hampered by cheap electrical power, which is sold at even lower rates in the summer.

If the cooling load ever exceeds the capacity of the system, up to four Energy Star vapor compressor electrical chiller units come on line in sequence. Each system operates as close as possible to full capacity to achieve the best energy efficiency at all times. This battery also serves as an emergency backup.
Daylighting

With 332 cloudless days per year at Hermosillo, sunlight is intense and uniform, hence daylighting has been used as a key design element of all the buildings. By eliminating the need for electrical lighting as much as possible, daylighting reduces energy consumption, carbon emissions, heat generation within the building, and operating costs. Astronomical north was determined and the buildings’ main axis set perpendicular to it. This optimizes sun control and daylighting and the orientation of the rooftop solar equipment.

The administration building uses three forms of light openings: skylights, shaded fenestration, and daylight ducts. During the day, these three systems work together to adequately and comfortably illuminate all main spaces throughout the building – even those on the lower level. Skylights, oriented northward to limit solar gain and fitted with diffusers to prevent glare, illuminate the offices of the top floor. The scalloped ceilings evenly distribute the light. An ornamental conical skylight crowns the central stairwell, brightly illuminating the vertical core of the building.

The skylights and the windows were designed to provide adequate daylight without inducing excessive solar gain. Various fenestration designs were modeled, tested, and fine-tuned at the “artificial sky” of the Bioclimatological Design Lab at the Universidad Autónoma Metropolitana (UAM) in Mexico City. All windows feature sheet-metal surrounds that protrude 0.6 meters from the facade, producing an effective 1.2-meter-deep recess at the windows. These shading devices block direct sunlight on glazed surfaces and also partially shade the walls.

An innovative product – Solatube – is used to conduct daylight into interior spaces on all floors of the building, including the lowest floor. 82 Solatube light ducts extend from the rooftop through the building to the ceilings of
the spaces to be illuminated. The ducts are lined with a reflective metallic film, and they conduct light with astounding efficiency. The ceiling-mounted diffusers are as bright as electric light fixtures, and the heat gain is negligible. The filtered sunlight creates a very pleasant atmosphere in the rooms. Motor-controlled baffles allow dimming when required.

An electrical lighting system with efficient LED fixtures is installed throughout the building to augment the daylighting. Artificial lighting is required only at night, on cloudy days, or where bright task lighting is needed.
The greatest water-saving measure at the Hermosillo plant is the management of production water. The water-efficient landscaping and underground drip-irrigation system are further measures. And the buildings are designed to add even more savings. Lavatories are fitted with ultra-low-flow fixtures. Urinals are waterless. Rainwater is collected from the rooftops, filtered, and stored in cisterns for irrigation and for fire-extinguishing water. Wastewater from showers, lavatories, and kitchen sinks is treated and reused for flushing toilets. Domestic soiled water is collected in septic tanks for anaerobic treatment and then released into a biological treatment pond. The treated water is used for irrigation.
A 200 kW photovoltaic system generates the power required by the administration building for lighting, laboratory equipment, the central control panel, computers, and other equipment. The photovoltaic panels installed on the roof of the office building and the adjacent carports represent the largest photovoltaic installation in Mexico. This green energy system avoids 750 annual tons of carbon emissions that would otherwise be produced by fuel-based power generation.

The buildings are designed to reduce electrical consumption in several ways. Daylighting drastically reduces the need for electric lights. All lighting fixtures are equipped with LED lamps. Most desktop computers were substituted by laptop equipment, and all electromechanical equipment was selected based on efficiency and quality. The 75-tonne chiller requires 4.3 kw, whereas a conventional 64-tonne chiller would require 50 kw. Total energy consumption of the administration building, not including the back-up air conditioning units, is 75 kW, compared with 183 kW for similarly sized conventional designs.
Construction materials

The buildings were constructed using standard materials and methods. Materials were selected based on local availability, cost, durability, ease of maintenance, and thermal performance. The materials themselves are conventional, not particularly environmentally friendly or low-gray-energy products.

Modular building systems were used for efficient manufacturing of pre-fabricated elements and swift construction. The factory produced elements, steel structural elements and prefabricated cement panels, were produced with a minimum waste of energy and raw materials. They were transported to the site for rapid assembly. The buildings are designed so that most of the materials can be separated and recycled after the buildings have served their useful life.

The buildings are steel framed, with concrete slabs on galvanized steel decking. Exterior walls assemblies measure 60 cm. The exterior finish is prefab fiber-cement panels and the interior finish gypsum board. Cavities contain 4 inches of insulation. Roofs are covered with metal decking, 4-inch polystyrene board, and light-gray membrane roofing.
Performance evaluation and certification

Since August, 2010, the administrative building and two comparable reference buildings in Hermosillo City have been monitored to ascertain the relative energy efficiency and indoor comfort. Twenty data loggers were set up to record indoor and outdoor temperatures and relative humidity. Readings are taken year round, day and night, at 30-minute intervals.

Local meteorological data is simultaneously collected from an automated station, and electrical and water consumption of the buildings is recorded. Evaluation of the data to date indicates that the cooling load of the building is 29 percent lower than similar reference buildings. The building certificate attests that energy use is 59 percent less than the norm.

Envelope thermal load in July 2011

Watts

0.00
50,000.00
100,000.00
150,000.00
200,000.00

1 2 3 4 5 6 7 8 9 10 11 12
The indoor temperature of the administrative building remains in the 21°C to 26°C range.

On March 11, 2011, all six buildings of the Hermosillo plant were certified under the Mexican Energy Efficiency Norm for nonresidential buildings (NOM-008-ENER).

At the beginning of the project, the design team intended to submit the six buildings for LEED\textsuperscript{1} certification, but this idea was dropped in consideration of the two-year processing time and the associated cost, approximately USD 250,000. That money was better spent in safety design, energy-efficiency features, and amenities that benefit the users.

\textsuperscript{1} LEED, Leadership in Energy and Environmental Design, is a globally recognized green building certification system developed by the U.S. Green Building Council.
Social, environmental and economic sustainability
The Hermosillo plant is essentially about cement, but it’s the people that make the plant – more precisely, 140 qualified people, 13 women and 127 men. All staff in positions of coordinators and technicians are experienced engineers. All operators have at least a high school education. Because the average education level is high, the size of the staff is relatively small.

The average age of the staff is 31. Nearly all are Mexicans and were recruited from other plants in Mexico, and all live in Hermosillo. Commuter buses for staff, chartered by Holcim Apasco, run ten times a day. Most managers commute by car, to suit the long and irregular working hours. Commuting by bicycle would be impractical and dangerous, due to road conditions and the climate. Bicycles, including transport tricycles, are available at the plant for on-site trips.

Because the plant is some 23 kilometers outside Hermosillo city, it has been well equipped to autonomously meet the physical needs of the staff. The cafeteria is open all day, serving well-prepared and tasty meals at breakfast, lunch, and dinner. Employees pay about USD 10 per month for meals. The plant has a medical station with a full-time doctor on duty. Employees are encouraged to visit the doctor for any medical needs,
whether injury, sickness, headache, or diagnosis of any symptoms. The plant has an ambulance on site at all times for emergency transport to Hermosillo hospital. The fitness room is available to all employees. It is located next to the medical station, so the medical staff can oversee and control the use of the equipment.

The working atmosphere in the administration building is pleasant. People take time to help each other. They stop and talk as they pass in the circulation areas. Such informal interaction is encouraged by the agreeable and spacious atmosphere of the lobby areas, each equipped with several seating groups for conversation and impromptu meetings.

The social engagement of the Hermosillo plant extends beyond the grounds. The plant particularly supports Mesa del Seri, its nearest neighboring community, ten kilometers to the west. Mesa del Seri is a poor farming village of 1,000 inhabitants, many with grave socioeconomic problems. The plant had a study of the village conducted to determine the social, economic, and physical needs, and supports the citizens of the desert village through the Unison project.
Respect for nature

The plant grounds, quarries, material storage areas, and belt-conveyor area occupy roughly ten percent of the 3,000-hectare site. The remaining ninety percent of this desert land has been treated as a conservation area. To compensate for the 265 hectares of land claimed for production, an equivalent area of disturbed land on the site was rehabilitated. These areas, identified in consultation with environmental authorities, had suffered from human intervention or erosion. The rehabilitation consisted of spreading excavation material and sowing indigenous grass species. All soil excavated during construction was reused on the site.

In the typical modus operandi, the general contractor wanted to begin construction by razing the land where the plant would stand, but the project team insisted that all significant trees and plants be saved. This was a voluntary decision, not a government requirement. Certain wooded areas of the plant grounds were fenced off and protected during construction. Some on-site roads were routed to preserve trees. In one case, a road was widened and the tree left in it.
Archaeological survey

Five known archaeological sites are on the larger plant property, and the authorities required investigation of these areas as part of the construction project. The five sites were systematically inspected to a depth of one to two meters for significant artifacts. The digging was done by archaeologists from the Instituto Nacional de Antropología e Historia (INAH), who recovered hundreds of artifacts, mostly arrowheads and crude implements attributed to the archaic period, dating to 5,000 B.C. The relics collected during the year of investigation were delivered to government authorities for preservation and display in museums. After being investigated, the dig sites were released without restriction. The excavation sites do not coincide with any production areas, so the investigation work could be conducted during the construction phase without causing interference or delay.

All major flora was removed by a team of biologists and transplanted elsewhere on the property or transported to a nursery for care until the plants could be replanted on the grounds after the construction work had finished. All significant plants (960 specimens) were removed from the 265 hectares claimed for production. They were replanted on the grounds, on the land to the east of the plant, and in the areas of archaeological excavation. One specimen is on the IUCN red list: guayacan (guaiacum coulteri). This tree was replanted on the plant grounds.

Animals found on the site were treated with the same care. All slow-moving animals, such as desert turtles, rattlesnakes, chameleons, toads, and tarantulas, were relocated to suitable nearby areas where plant activities will not disturb them. Each animal was documented. 66 specimens were rescued, 11 of which are on the IUCN red list. A new pond was built and connected to the existing pond near the plant to collect rainwater and support wildlife on the site.
The CAPEX budget for the entire plant, including the buildings, was approved with the stipulation that there would be no additional funds available. Thus the planning team had to start by building a contingency budget. Designing a “low cost” version of the buildings was considered the wrong approach for two reasons: lowest-cost construction usually leads to more expensive life-cycle costs, and money invested in environmentally sustainable projects brings benefits beyond those that one can describe with a price tag. Green building is a fundamentally sound investment, especially considering the unquantifiable future costs of global warming.

The economic stance adopted was to seek not low cost but lasting value. Efficient passive design costs little extra and substantially reduces the cooling load, thus allowing cooling systems to be downsized – or, as in this case, allowing the opportunity for alternative systems. The initial investment in energy-efficient features of the building drastically cuts operating costs from day one, as the photovoltaic system produces electricity, the solar concentrators drive the air conditioning system, and daylighting...
reduces electrical consumption. The intelligent engineering and architectural design of the buildings reduces energy consumption by half. The energy performance certificate attests to savings of 50 to 60 percent for the six buildings.

The plant was constructed within budget. Building materials such as fiber-cement facade panels, LED lamps, and ceramic tile flooring require very low maintenance and promise long service life. These features reduce maintenance and operating costs of the building.

Investment in alternative technologies such as photovoltaic systems and solar-driven air conditioning is economically feasible and technically sound in the desert, where the intense heat and radiation are abundant, free, and limitless natural resources. The payback period for photovoltaic systems is quite long, when calculated using current Mexican power rates. On the other hand, energy costs are continually rising, and the system represents a long-term hedge against inflation.
The Holcim Apasco Hermosillo plant is a landmark for Holcim. As one of the Group’s newest, most attractive, and most innovative plants, with outstanding performance across the board, it can be seen as a flagship plant. It raises the bar for cement plant design and engineering, excelling in many categories: safety design, cost efficiency, future adaptability, energy and water efficiency of production, sustainable design of all buildings, environmental sensitivity, leadership in use of innovative technologies, high-quality architecture, and a focus on quality, especially evident in the commissioning phase.

The plant is a proverbial oasis in the desert, albeit an industrial oasis. It radiates a positive spirit of place. The visitor’s initial impression is the visual one: a brand new industrial plant gleaming in the Sonora sun. But closer encounter reveals the underlying values expressed in the facility: responsibility, professionalism, care for people, and respect for nature. This carefully constructed place has a social and psychological influence conducive to employee well-being and efficient manufacturing.

The story could have been a different one. Instead of being an oasis, the plant could have been a mere production machine, hidden away in the desert. No one need see whether working conditions are attractive, resources are being conserved, high standards are being maintained, or green architecture is being built. Holcim’s decision to build for sustainability was a voluntary choice driven by corporate values.

Although Hermosillo features many commendable green features, to call the plant itself green would be an overstatement because cement production is a process that accounts for approximately five percent of global CO₂ emissions. In weighing the trade-offs, it must not be overlooked that
concrete is one of the most durable of all building materials and that in many applications it is indispensable and without substitute – simply a necessity in today’s world. Until a zero-carbon technology is found for cement production, emissions reduction represents an improvement in the process, and Holcim is an industry leader in reducing emissions. Holcim voluntarily reduced its specific CO₂ emissions by 20.1 percent from 1990 to 2008, and having reached its target of 20 percent two years early, continues to improve average Group-wide environmental performance with each new plant by applying the best available technologies and setting rigorous standards.

Thinking about the needs and welfare of future generations as we shape our world today sometimes tends to be forgotten, especially in times of austerity. The Hermosillo project is a reminder of the importance of long-term thinking. Examples include the strategic location of the plant, day-one preparation for a second kiln line in the future, the allotment of ample time for commissioning, and the investment in energy-efficient equipment and building systems. Low emissions, resource efficiency, and groundwater conservation might not seem drastically urgent to some of us today, but these will be increasingly crucial issues to future generations. Long-term thinking is what sustainability is all about.  

Daniel Wentz
Assessments by building professionals
Specialists on site (from left): Matt Helms, Hermosillo Maintenance Manager; Hans-Rudolf Schalcher, Engineer, Switzerland; Marc M Angélil, Architect, Switzerland; Pedro Lluch, Project Manager Hermosillo Plant; Bruno Stagno, Architect, Costa Rica; Vanderley M John, Engineer, Brazil; Angelo Bucci, Architect, Brazil; and Juan José Dominguez, Hermosillo Plant Manager.
On July 11, 2011, immediately after the South America regional jury for the Holcim Awards for Sustainable Construction 2011 had convened and completed its work in Mexico City, five of the jury members visited Holcim Apasco’s Hermosillo cement plant, then only four months old. After undergoing a safety induction, mandatory for all visitors at all Holcim plants, the group enjoyed a presentation of the plant, and after putting on the appropriate personal protection equipment (safety helmet, glasses, vest, boots), the group was given a comprehensive tour of the grounds. During the tour, the entire production process was explained by several Holcim technical specialists, and the visitors had plenty of time to ask questions and talk in depth with the Holcim engineers as the group walked from one area to the next. The topics of most discussions were technical, inspired by the machinery and processes being explained.

Each of the visiting building professionals was impressed by what he saw and learned, and each was inspired by different aspects of the facility: the importance of the plant as an example to learn from and copy, the innovative architectural response to the desert climate, the application of advanced technology in balance with respect for people, the significance of applying sustainable design to all parts of the plant (even those that seem less significant), and the eminent status of the plant as a new global landmark of sustainable development in the cement industry.
“The Hermosillo cement plant by Holcim Apasco redefines our notion of industrial sustainability. It is an amazing self-containing enterprise, utilizing waste materials such as used tires in order to heat the kiln, using mostly energy from the sun for the buildings, and incorporating sustainable technologies throughout. I think what we are approaching here, in this isolated climate, is the Masdar City of the cement industry.”

Marc Angélil, Dean of Architecture, Swiss Federal Institute of Technology (ETH Zurich), Switzerland
“I see the administration building as a laboratory test. It provides us with experience which could be applied to several buildings in different situations. It’s not so common to work in a place with an average temperature of 32° Celsius. The plant’s architecture is in fact secondary; everything is actually about production technology. But the architecture that comes from this is so beautiful – this plant is an amazing work of architecture.”

Angelo Bucci, Architect, Principal, spbr architecture, Brazil
“The usual approach in industry is to have a very efficient industrial plant and treat the auxiliary buildings with less care. But here everything is coherent, and that is a great contribution. Even if the energy demand of the buildings is only 0.5 percent of the total energy demand of the plant, it does not mean the buildings are insignificant. Investing in sustainable buildings is the right way to accumulate knowledge that others can use.”

Vanderley John, Engineer, Professor, University of São Paulo, Brazil
“Since I have been working as an engineer, I have seen dozens of cement plants around the world, from Indonesia to Argentina. But I never saw a plant like this one. It’s absolutely exceptional, not only with regard to the production line but especially with regard to how they value and estimate people. One can see this when you go through the buildings and look at how people are accommodated.”

Hans-Rudolf Schalcher, Engineer, Professor em., Department of Civil, Environmental and Geomatic Engineering, Swiss Federal Institute of Technology (ETH Zurich), Switzerland
“The administrative building is progressive in the way the design responds to the extremely hot climate. The architects first developed the basic design and then added suitable technologies to achieve a good and comfortable indoor environment. The lighting and air conditioning systems incorporate the latest technologies that are just entering the market. Indoor illumination is very smooth, and the temperature is comfortable.”

Bruno Stagno. Architect, Principal, Bruno Stagno Arquitecto, Costa Rica
# Project team

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Building design team

Holcim Apasco project manager
Pedro Lluch, engineer

Architectural design
Estudio fi
Horizonte Digital
Grupo de Arquitectura Bioclimática
Ital Vantanas

Fernando Ituarte Verduzco, architect
Octavio López Márquez, architect
Francisco Plata Ortega, engineer
Aníbal Figueroa Castrejón, engineer and architect
Luciano Bove, engineer
Fernando Ituarte Ortega, architect

Construction supervisors
Antonio Valdés, engineer
Roberto Rivera, engineer

General contractor
Promotora y Desarrolladora de Construcción
Promoting and rewarding sustainable construction

The Holcim Foundation for Sustainable Construction promotes innovative approaches to sustainable construction. The objective of the Holcim Foundation is to encourage sustainable responses to the technological, environmental, socioeconomic and cultural issues affecting building and construction, regionally as well as globally – through a range of initiatives.

The Holcim Awards is a series of international competitions for future-oriented and tangible sustainable construction projects. They recognize any contribution to sustainable construction – irrespective of scale – in architecture, landscape and urban design, civil and mechanical engineering and related disciplines. Prize money of USD 2 million per three-year competition cycle encourages and inspires achievements that go beyond convention, explore new ways and means, and draw attention to and identify excellence. The Awards competition is conducted in partnership with some of the world’s most renowned technical universities* who lead the independent competition juries to evaluate entries according to the “target issues” for sustainable construction. www.holcimawards.org

Updates on projects associated with the initiatives of the Holcim Foundation are regularly published and explain how projects have evolved from inspired ideas into tangible flagships of sustainable construction. www.holcimprojects.org

The Holcim Forum is a series of symposiums for academia and practitioners to encourage discourse on the future of the built environment. It supports sustainable construction in the scientific field, among experts in the construction sector, business and society. www.holcemforum.org

* see details at: www.holcimfoundation.org/univ
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Photos

Alain Bucher, Berne, Switzerland
Nikkol Rot, Zurich, Switzerland (pages 27, 29, 31, 78, 80)
Holcim Apasco, Mexico (pages 4, 22, 34)

Sources

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