

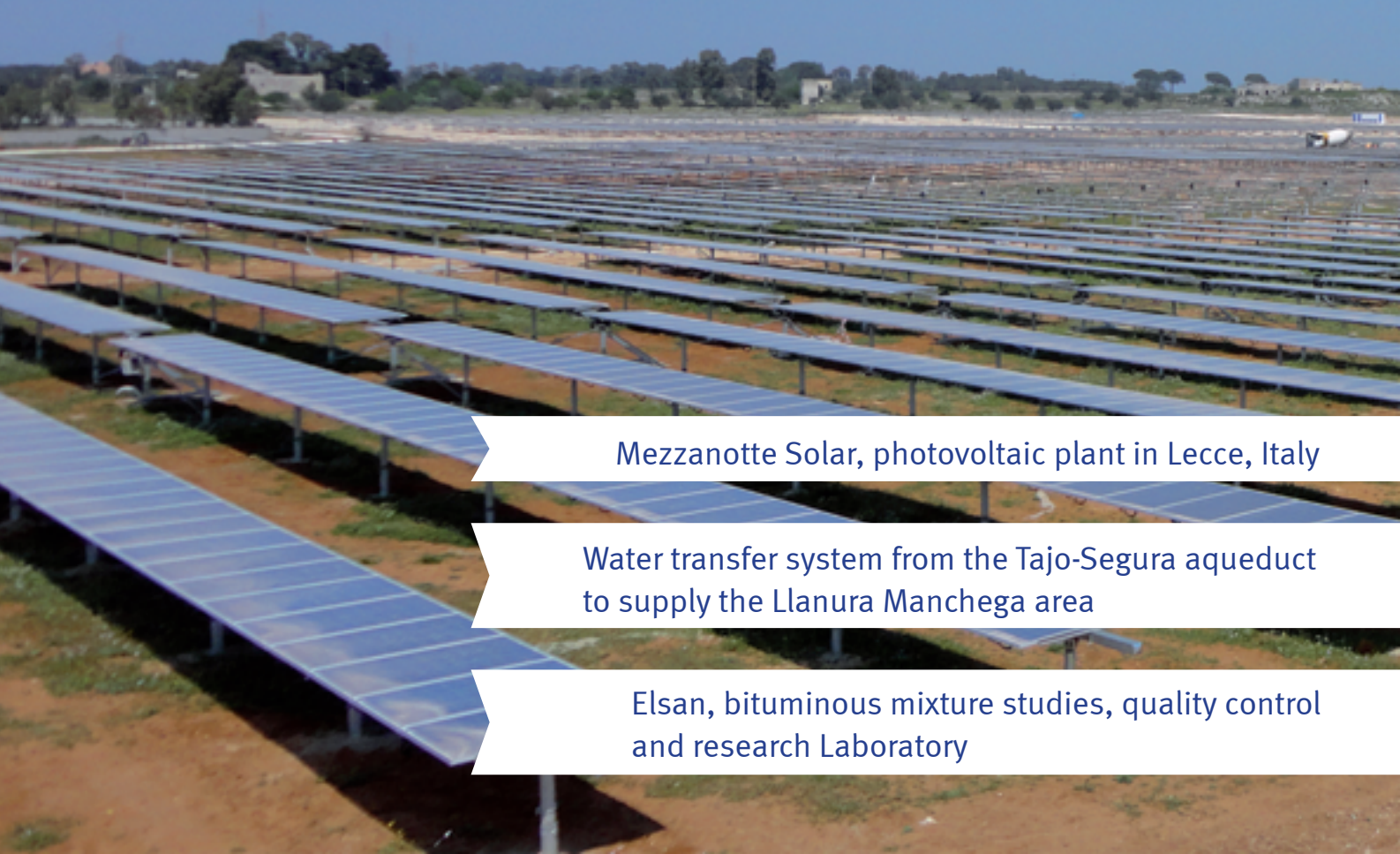


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Mayakoba consolidates its international prestige

tecno

Grupo OHL Magazine

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With the execution of the Mezzanotte Solar power plant, located in the vicinity of the Italian town of Lecce, Grupo OHL, through its OHL Industrial division, has designed, built and commissioned a solar park capable of generating 7,287,98 MWh, representing carbon emission savings in the region of 26,400 t of CO₂. In addition to its power generating characteristics it is worth highlighting the use of screw piles, a pioneering construction element allowing installation in a wide diversity of soils and ensuring the proper operation of the sun tracker.

Another significant project undertaken by OHL, which stands out for its complexity, is the *water transfer project from the Tajo-Segura aqueduct*, as part of the action plan undertaken by Confederación Hidrográfica del Guadiana (Guadiana water board) to add new water resources to the La Mancha Plain. Said project

constitutes the backbone of the system that will allow the exploitation of water resources from the Tajo headwater reservoirs via the Tajo-Segura aqueduct.

An example of Grupo OHL's constant commitment to R&D&I is the Asfaltos y Construcciones Elsan quality control and research laboratory, a leading facility in the Spanish bituminous mixtures sector, which carries out different activities related to the quality of road surface construction.

Also featured in this issue is Mayakoba, which continues to receive praise from Spanish and international bodies and institutions for offering a combination of sustainability -Mayakoba is a world leader in this field- environmental protection and a significant commitment to the community through different social initiatives.

Luis García-Linares
General Corporate Manager



Mezzanotte Solar photovoltaic plant in Lecce, Italy



Designed and built by OHL Industrial, it has an annual power generation capacity of 7,287.98 MWh, with carbon emission savings of around 26,400 t of CO₂

Mezzanotte Solar photovoltaic plant in Lecce, Italy

Grupo OHL, through the Power arm of its OHL Industrial division, extends its track record in the field of renewable energies with the design, construction and commissioning, in June 2011, of the Mezzanotte photovoltaic plant in the Italian region of Puglia, a strategic location due to its climate, with a solar irradiance exceeding 1.700 kWh/m². The project comprises a total of 17,640 polycrystalline panels mounted on a single-axis solar tracking system, providing a peak power output of 3,969 kWp. In addition to its power generating characteristics it is worth highlighting the pioneering use in its construction of screw piles. A variation of the traditional driven piles, they can be installed in a wide diversity of soils of different hardness, meeting the traction, torsion and deflection demands of the solar tracker for its proper operation.

Sited on the Masseria Mezzanotte estate, 2 km to the west of the Italian town of Lecce, known as the Florence of the south, the Mezzanotte Solar photovoltaic plant covers an area of almost 17 ha and has a total power generating capacity of 7,287.98 MWh per year, equivalent to the power supply to 700 households, approximately 18 % of the homes in the nearby town of Lecce. Moreover, the facility is capable of generating clean energy, with carbon emission savings on the order of 26,400 tons of CO₂, equivalent to the emissions of 1,500 cars traveling 18,750 km/year.

Located in the region of Puglia, in the south of Italy, this plant benefits, like a great part of Spain, from an annual solar irradiance in excess of 1.700 kWh/m², making it an ideal site for the exploitation of solar power resources.

Recognising its potential, the Italian government drafted in 2001 the Energy Bill for Renewable Sources, passed into law in February 2006, stipulating the so-called *Conto Energia* (energy quota for renewable technology).

In the period to 2010, when the *Secondo Conto Energia* ended, a total of 209,493 photovoltaic facilities had been connected to the grid, according to data from the GSE (the Italian government's electric power service management body) as of June 4 2013, of which 83 % were conventional solar parks with their panels facing the sun in a fixed position.

To promote the use of new technologies, the GSE, in its third review conducted in 2010, granted special protection to the implementation of innovating systems for the

exploitation of renewable energies, which led to the development and installation of power generating systems based on photovoltaic technologies enabling a combination of low Operation and maintenance (O&M) costs and high power yields.

Theoretical basis of the project

The Mezzanotte Solar photovoltaic generation project was designed and carried out in accordance with the criteria established by the *Terzo Conto Energia*, effective since January 2011, seeking to achieve the maximum production efficiency and reduction of installation and O&M costs.

Therefore, the facility was designed selecting a single-axis solar tracking system as the supporting structure for the photovoltaic panels.

Both the direct and diffuse components of solar radiation are exploited for power generation. Direct radiation is that originating from the solar source, without any intermediate reflections or refractions. Diffuse radiation, on the other hand, is generated by the multiple solar reflection and refraction phenomena taking place in the atmosphere, clouds and other atmospheric and terrestrial elements. The overall incident solar radiation is the sum of these two components.

While direct radiation may be reflected and concentrated for its use, it is not possible to concentrate diffuse light, coming from all directions. Photovoltaic systems, whose purpose is to convert the overall solar radiation into electric

power, are designed according to the efficiency of capture of this radiation, ranging from the simplest to the most complex system, capable of maximizing the capture factor. These systems can be classified according to their performance and their position relative to the movement of the sun:

- Photovoltaic modules horizontal to the Earth's surface. This is the simplest model and is used as a reference standard.
- Photovoltaic modules set at a fixed angle, optimized for the entire year.
- Photovoltaic modules installed on a single-axis solar tracking system.
- Photovoltaic modules installed on a dual-axis solar tracking system.

On fixed systems the panels are installed facing the sun in a permanent position, allowing optimization of their inclination to achieve maximum yield throughout the year. To do this a number of factors are taken into account, such as the latitude at which the solar facility is located. For instance, for solar plants located on the 40th parallel north (latitude of Madrid), the optimal fixed inclination angle the whole year round would be 30°. These adjustments result in a 14% increase in the direct solar radiation capture yield with respect to the standard installation.

Single-axis solar trackers

The installation can be implemented in a more complex

manner, thereby enhancing the yield of the photovoltaic system. This involves the use of solar trackers – mechanical devices capable of orienting the panels such that they remain as perpendicular as possible to the sun's rays, tracking the sun from the east at sunrise to the west at sunset. This allows for a much more efficient exploitation of direct solar radiation.

There are many different solar tracking systems available on the market. These are divided into two main groups according to the degree of movement they allow: single-axis solar trackers and dual-axis solar trackers.

The former have a degree of freedom to follow the sun, and the solar capture surface is mounted on an axis that can be horizontal, vertical or oblique, capable of rotating and enabling solar tracking. The most widely used, on account of its complexity/yield ratio, is the horizontal north-south axis configuration. The rotation is adjusted so that the normal to the surface coincides at all times with the terrestrial meridian containing the sun.

Solar trackers are used; these are mechanical devices capable of orienting the panels such that they remain as perpendicular as possible to the sun's rays.

The advantages of this type of system include an increase in the direct solar radiation capture efficiency by approximately 35% relative to the standard reference installation (modules horizontal to the Earth's surface) at a lower cost and with a simpler, easier installation. However, they provide more inaccurate sun tracking and the energy captured is lower than with other sun tracking systems.



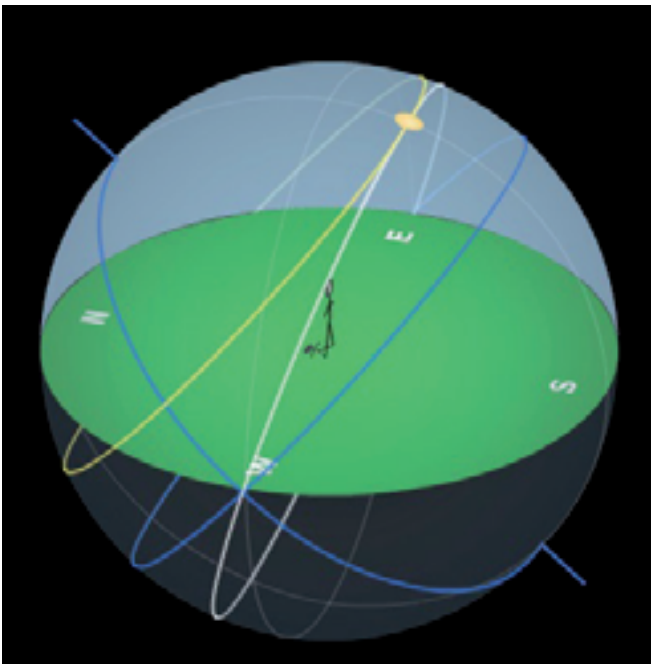
Dual-axis solar trackers

Dual-axis solar trackers have two degrees of freedom and enable full tracking of the sun, in terms of inclination and azimuth angle, maintaining the solar capture surface perpendicular to the sun at all times. They are more accurate than single-axis systems and the direct solar radiation capture efficiency is enhanced by up to 67% with respect to a standard installation. Their main disadvantages are the high installation, operation and maintenance costs required.

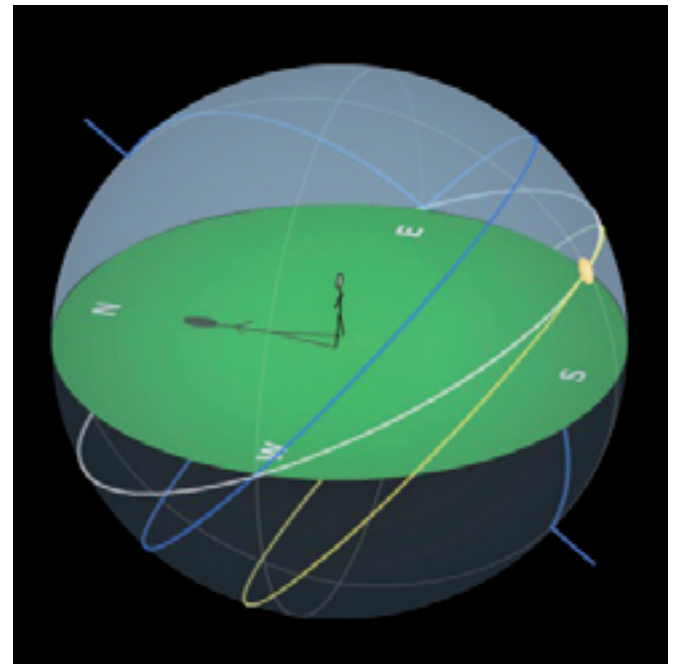
The type of solar tracker selected will depend on a number of factors including the installation and future maintenance costs, specific local environmental conditions and output expectations

The type of solar tracker selected will depend on a number of factors, including the installation and future maintenance costs, the land area available, specific local environmental conditions and output expectations, among others.

The Earth's inclination relative to the vertical axis causes the apparent height of the sun for an observer standing at the same point on the Earth to be higher or lower depending on whether we are in the summer solstice (June 20-21) or the winter solstice (December 21-22), respectively.

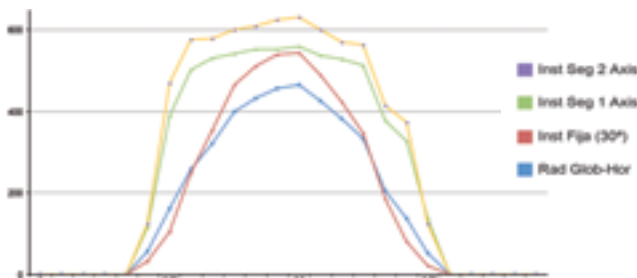


Apparent height of the sun at 12:00 hours on June 21st, according to an observer standing on a point along the 40° N parallel.



Apparent height of the sun at 12:00 hours on December 22nd, according to an observer standing on a point along the 40° N parallel.

Summer Solstice (06/21)



Winter Solstice (12/22)



Comparison of the instantaneous power generated by solar panels mounted on different solar tracking systems.

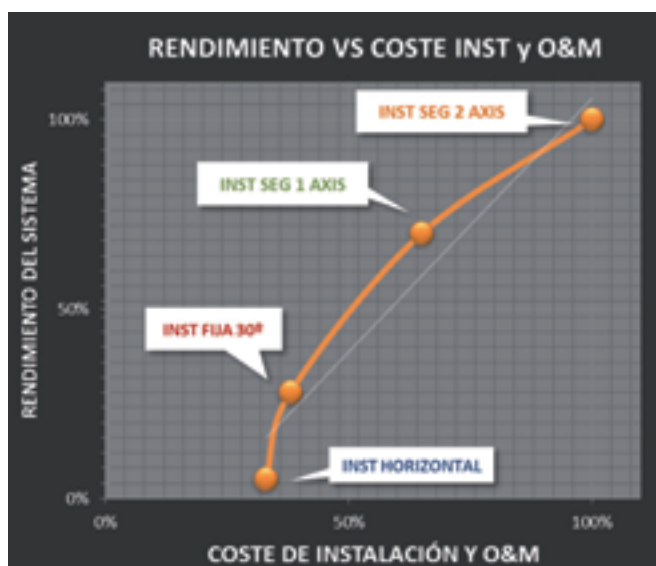
In terms of solar radiation capture efficiency, each graph shows a comparison of the production capacity of each of the photovoltaic systems described for the two key days in the year.

Graph 1 shows the production obtained in the summer solstice (June 20-21); while graph 2 shows the production that would be obtained during the winter solstice (December 21-22), the two periods during which the sun reaches its highest and lowest apparent height in the sky, impacting the operating conditions of these various types of equipment.

Comparison between the most widely used solar tracking systems

	Advantages	Disadvantages
Overall Rad-Horizontal	V. Low installation and O&M costs	V Low electrical yield
Fixed Inst (30°)	Low installation and O&M costs	Low electrical yield
1 Axis Tracker Inst	Medium installation and O&M cost	Medium electrical yield
2 Axis Tracker Inst	High installation and O&M costs	High electrical yield

System yield vs. installation and O&M costs



Based on the above considerations, it can be established that photovoltaic plants with a single-axis solar tracking system would have the best yield/cost ratio, especially with regard to O&M costs, as these can increase by a factor of two for projects incorporating dual-axis solar trackers.

Another element that needs to be taken into consideration is the availability of land and the type of terrain, which affect the shade calculations. Said calculations will determine the final distribution and layout of the solar panel arrays and avoid to the maximum pos-

sible extent the shades cast by each row on the adjoining ones, thereby minimizing the production losses caused by said shadows on the panels.

By way of an example, the design of a plant takes into account that on the most unfavorable day of the year, December 22, the modules must not have more than 5% of their useful solar capture surface covered by shades, as a higher percentage would cause an unacceptable loss in production and considerably hinder the operation of the panel.

Design of Mezzanotte Solar

For the Mezzanotte Solar project, various factors were taken into account to determine the type of installation, including the price of the generated power exported to the grid, the power output forecast, the type of photovoltaic modules, the land area available for the photovoltaic installation and the soil and terrain conditions, among others.

For its part, the client, SunEdison, carried out studies whereby established the initial premise of obtaining a

At Mezzanotte Solar, an EPC project, a total of 17,460 polycrystalline panels mounted on a single-axis solar tracking system were installed, with a total peak power output of 3,969 kWp

plant power generation capacity reaching 7,287.98 MWh per year. Upon completion of such studies, OHL received the commission of carrying out the photovoltaic project on an EPC basis, with a total of 17,640 polycrystalline panels mounted on single-axis solar trackers installed, with a total peak power output of 3,969 kWp.



Detailed view of a single-axis tracker installed in Mezzanotte Solar.

The execution of the solar park project included all the earth movement works required for the installation of the solar trackers, the supply of all the electrical and electronic control equipment, the connection of the plant to electrical utility ENEL's power distribution grid

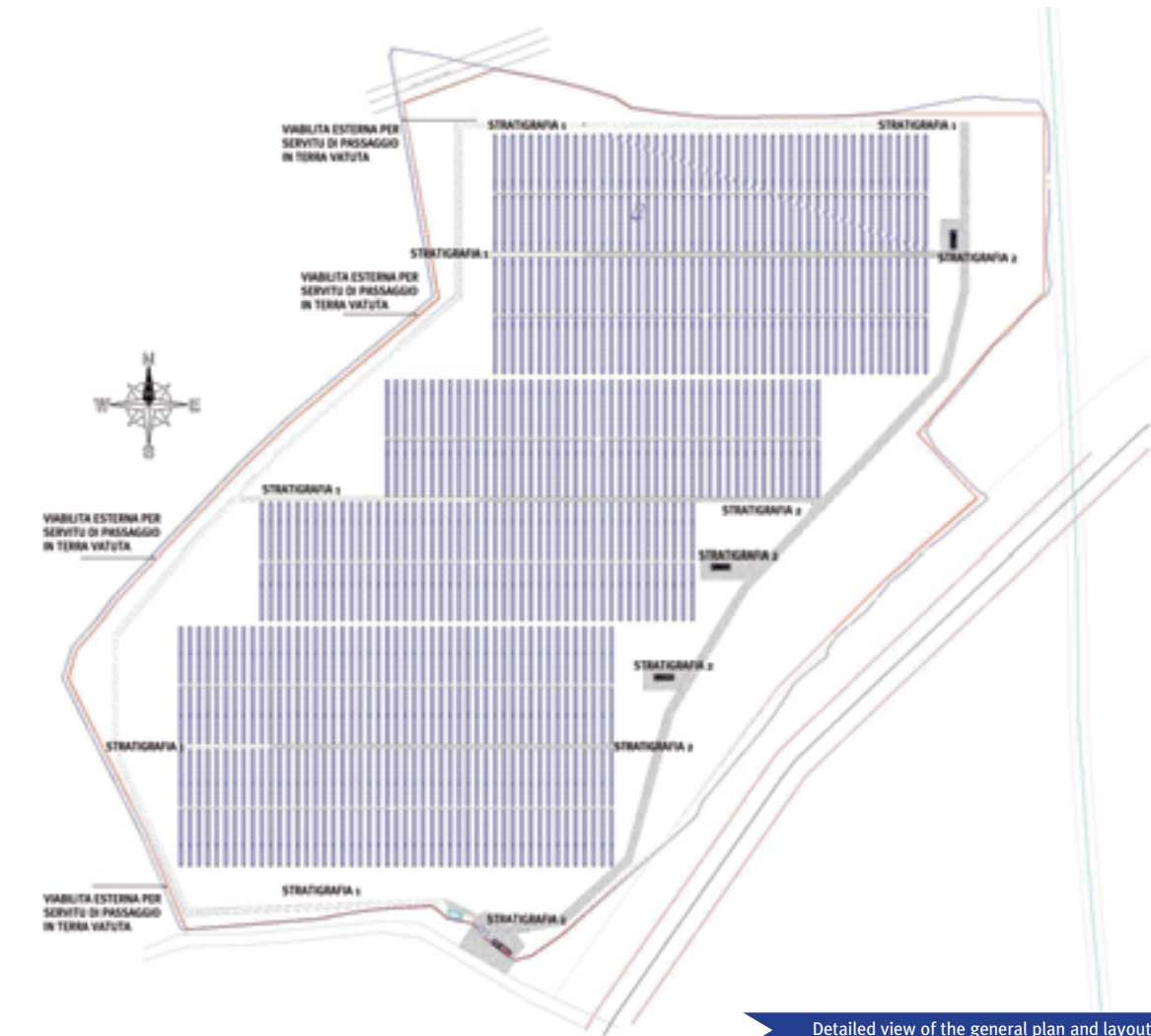
and the startup and adjustment procedures to ensure the proper operation of the plant according to the strictest standards of execution implemented by OHL in all the projects it carries out.



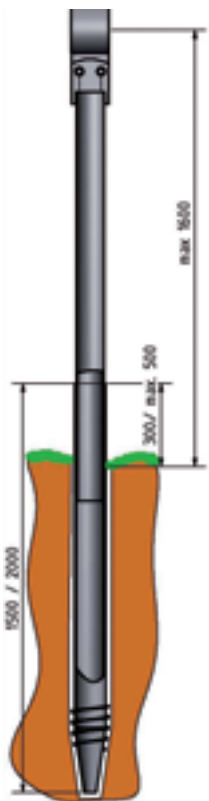
Orthophoto of the power generation plant site one year prior to the commencement of the works by OHL Industrial Power, 2010.



Basic schematics of a photovoltaic solar system connected to the grid.



Detailed view of the general plan and layout of the photovoltaic park.



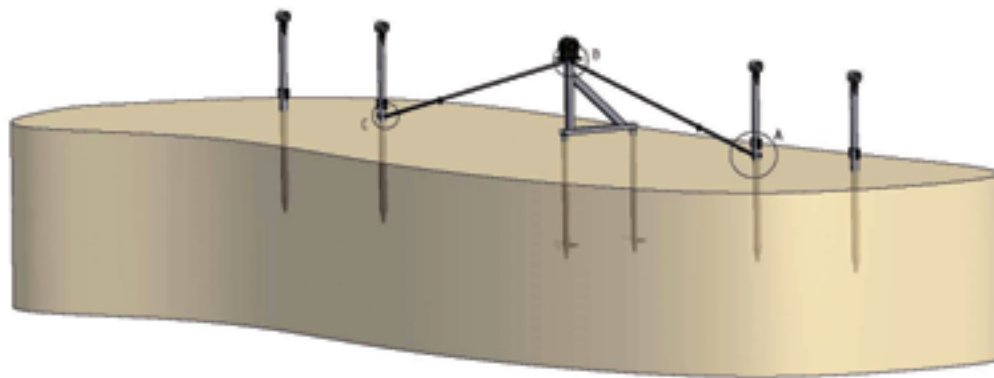
Grupo OHL and its commitment to R&D

OHL Industrial maintains a firm commitment to R&D, as evidenced by the constant search for solutions tailored to the specific needs of each individual client. An example of this are the improvements implemented by the Group's division at Mezzanotte Solar, including the optimization of the foundations of the solar tracker used.

Also, during the construction of the facility, the company pioneered the use of a variation of the traditional driven piles, known as screw piles, whose features allow installation in a wide diversity of soils of different hardness, ensuring that the traction, torsion and deflection demands of the tracker for its correct operation are fully met.

The use of screw piles has major advantages, such as reducing the earth movement work required, since the pile itself allows adjustment on the Z axis, ensuring that minor

For the construction of the facility, a variation of the traditional driven piles was used, known as screw piles – a pioneering solution implemented by OHL Industrial Power



Detailed view of screw pile and mechanical solution for the N-S torsion nodes of the tracker rotation axles.

variations in the terrain will not affect the alignment of the tracker's axis of rotation. The tracker's most critical points, subject to the highest mechanical demands, are at the centre of the N-S axle, where the torsion nodes of the axle itself are located. To address this, a very simple solution was developed and implemented, which ensures that the mechanical stresses demanded by the tracker are perfectly transmitted to the ground.

The use of this type of foundations reduces the environmental impact on the soil by minimizing the earth movement work required. It also allows the solar park to be dismantled at the end of its service life, restoring the natural conditions of the soil in a simple, swift process.

Another major advantage of this type of foundation is that it allows terracing, reduces the final movements required and cuts costs and execution

times. A total of six single-axis solar trackers were installed, comprising 25 rows each, giving a total of 150 rows of solar panels.



Completed installation. Detailed view of solution adopted for tracker torsion nodes the tracker rotation axles.



Another of the improvements adopted in the development of the Mezzanotte solar park is the implementation of a SCADA (Supervision, Control and Data Acquisition) control system capable of controlling the production levels and the status of each of the photovoltaic panel arrays making up the plant. This system allows full monitoring of the status of the photovoltaic plant, allowing the detection of any potential operation failures before they occur, thereby preventing the loss of power generation associated with a fault.

Another variation involves the use of prefabricated concrete structures to house the electrical equipment, including direct/alternating current inverters, step-up transformer units and, in general, all the control electronics for the plant.



Detailed view of array junction boxes.

Following completion of all the park installation work, OHL completed the medium voltage power line linking the park with the ENEL distribution grid. Finally the photovoltaic plant came into operation in June 2011 and, following all the adjustments and fine tuning required, was handed over to the client in July that same year.



Inside view of a transformer station.
Direct/alternating current inverter room.

Operation and maintenance of Mezzanotte Solar

Following the execution of the project, OHL Industrial took charge of the operation and maintenance of the solar park for two years. During this period, thanks to the exacting O&M standards implemented, the plant's operating parameters were optimized, the transformer station cooling and ventilation systems improved and the degradation suffered by the photovoltaic panels monitored. Also, preventive cleaning of the modules was carried out at the most suitable times of the year to counteract high temperatures and suspended dust particles. All of this has led to an increase in the plant yield of at least 3% above assured levels.



One of the park transformer enclosures.

Water transfer system from the Tajo-Segura aqueduct
for the supply of water to the Llanura Manchega area



Aerial view of upper dock in the finishing stage of construction.

The project, executed by Grupo OHL, will contribute to the water supply for a population exceeding 500,000 people from around 60 towns in the provinces of Albacete, Ciudad Real and Cuenca

Water transfer system from the Tajo-Segura aqueduct to supply the Llanura Manchega area

The project is part of an action plan aimed at meeting the water supply needs of the Llanura Manchega (La Mancha plain) area, through the transfer of water from the upper basin of the Tagus River running along the Tajo-Segura aqueduct (ATS). The project includes the construction of an upstream regulation reservoir, a main pipeline, a secondary pipeline to the Gasset reservoir, connections, branch lines, automated systems, affected infrastructure, and safety and health. The total network is to be completed with secondary distribution branch lines and a purifying plant at the head of the pipeline to avoid the need for similar facilities at each population center supplied by the system.

The upper basin of the Guadiana, located upstream of its confluence with its tributary on the river's left hand bank, the Jabalón, is known for its singularity. Its climate and geology play a major role in shaping its hydrographic structure, leading to the sparse hydro-geological features of a large part of the region. Water resources mainly originate from the underground aquifers, especially the Mancha Occidental and Campo de Montiel aquifers, internally connected to each other. These aquifers are linked to a number of natural enclaves of high environmental value located in this region: Tablas de Daimiel National Park, Lagunas de Ruidera Natural Park and other lake complexes.

Overexploitation of these aquifers has led to a decline in water head levels and the disconnection of the aquifer water from superficial water courses, causing the disappearance of the Ojos del Guadiana natural springs and significantly reducing the supply of water to the lakes in Lagunas de Ruidera and Tablas de Daimiel. Moreover, such overexploitation has contributed to the deterioration, pollution and degradation of the water quality. This is compounded by low rainfall over a long period of time, which has prevented a minimum recovery of one of the country's major hydro-geological units.

In view of this dire situation the Guadiana Water Board, put together an action plan through its Water Council in April 1995, which was submitted to the then Ministry of Public Works, Transport and the Environment (MOPTMA). The plan was aimed at solving the existing problems in supplying water to the local populations, as well as those suffered by Tablas de Daimiel and other wetlands, owing

to inadequate water resources, in terms of both quality and quantity.

Among the undertakings contemplated in said plan, it is worth

highlighting the *Water Transfer project from the Tajo-Segura Aqueduct to contribute water resources to the Llanura Manchega area*, executed by OHL and constituting the backbone of the system that will allow the exploitation of the water resources of the reservoirs on the upper basin of the Tagus river through the Tajo Segura aqueduct (ATS). The plan calls for tapping water from the ATS in the section upstream of the Gigüela aqueduct, at a sufficient altitude to carry the water by gravity to most of the towns supplied. It is therefore an urban water supply infrastructure designed to meet the demand of the more than 500,000 inhabitants of some 60 municipalities in the provinces of Albacete, Ciudad Real and Cuenca.



The system will allow the exploitation of the water resources of the reservoirs of the upper basin of the Tagus river through the Tajo-Segura aqueduct



Subsequent phases are planned to complete the total network with the following projects:

- Secondary distribution branch lines, including the connection of the La Mancha pipeline -main line plus secondary pipeline- with the various towns. Work is currently under way on the construction of the northwest branch line, while the rest of the branch lines are currently in the tendering and preliminary study stages.
- Water purifying plant at the head of the pipeline to avoid the need for similar facilities at each of the towns supplied. The project, carried out by a temporary joint venture between OHL and Inima, is in an advanced state of execution.

Contract award process

The project was put out to open tender and provisionally awarded to the firm Obrascón Huarte Lain on April 1st, 2005, with a total budget of €127,412,891.00.

The tender project was executed with the participation of the Ministry of Public Works, Transport and the Environment, through the Directorate-General for Hydraulic Works, Guadiana Water Board.

Work on the project commenced on April 4th, 2006, with an initial execution deadline of 48 months. Following No. 1 Amendment Proceedings approved in 2007, the deadline was extended by a further period of one year, and the completed facility was finally handed over in May 2011, within the established deadline.

A complementary works project is currently under way, scheduled for completion by the end of 2013.

The total worth of the main project, including VAT and taking into account price revisions and final settlement, amounts to the sum of €196,317,341.46. To this must be added the €33,028,130.64 budgeted for the complementary project, not including price revisions and final settlement.

Scope of the project

The project is part of the set of measures undertaken to assure the water supply of the Llanura Manchega area with water from the upper basin of the Tagus river, tapped from the ATS. Said project is the backbone of the system, essentially comprising the following elements:

- Upstream regulation reservoir.
- Main pipeline.
- Secondary pipeline to Gasset reservoir.
- Connections, branch lines, automated systems and affected infrastructure, among others.
- Safety and health.

Given the linear nature of the project, with work being conducted on many sites simultaneously, the team in charge of supervising the execution of the works totaled 150 professionals. Exceptionally, at certain stages this number rose to 250 people, including collaborating companies.

The dam is fully equipped with all the safety elements required by a structure of its type, and has three possible water capture sources from the Tajo-Segura aqueduct:

- Direct connection through a branch canal operated by two Taintor sluice gates, releasing the water via a chute. .
- Lateral spillway 80 m in length located on the upstream side of the direct connection described above, designed to enable evacuating through it the 33 m³ /s theoretical maximum flow rate of the ATS. Through this lateral spillway, the entire flow of the ATS can be diverted to the reservoir, thus constituting an essential safety device of the aqueduct itself.
- Direct link by means of a pipe connecting the ATS with the reservoir collection outlet. This bypass is a 1,800 mm diameter cast iron pipe starting from a branch junction located downstream from the reservoir main water collection system.

As regards the treatment of the reservoir bed, following several studies it was decided to completely line it with

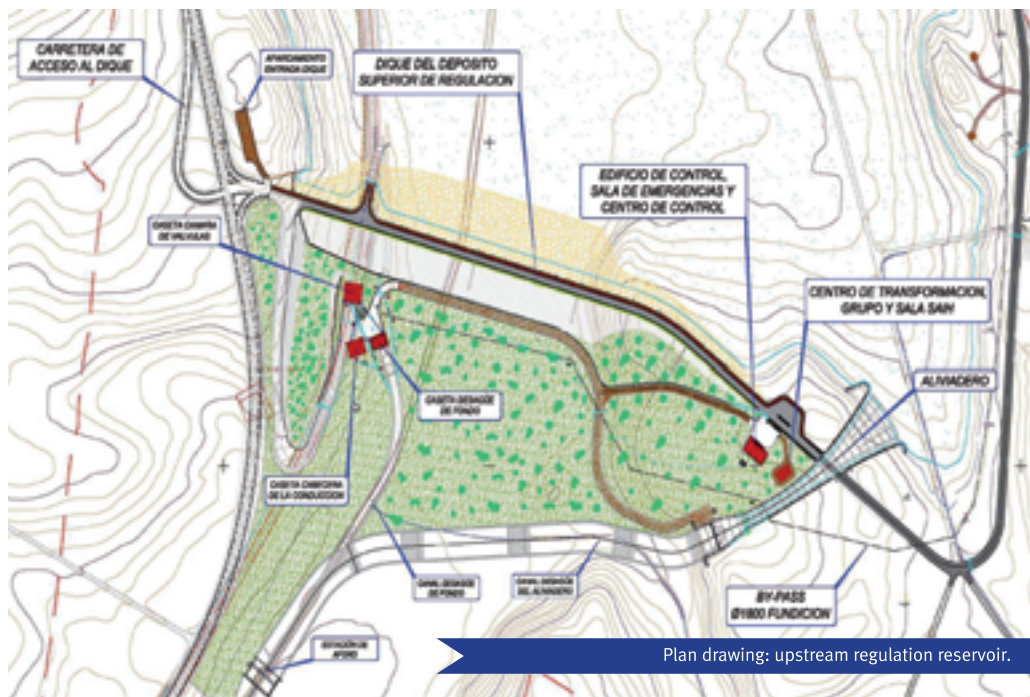
a 0,75m thick layer of clay that prevents leaks in any direction, assuring the water tightness of the reservoir.

Main pipeline. Originating from the dam outlet- pipeline head house- the main pipeline runs over a distance of 117.6 km, and from it, the water will be distributed by means of the projected branch lines to some 60 municipalities. The pipe used, made of ductile cast iron, starts with a diameter of 1,800 mm for 24.49 km; followed by a 1,600 mm diameter tranche over the next 54.16 km, after which the pipe diameter goes down to 1,400 mm for the remaining 34.04 km. The division

into different pipe diameter tranches was calculated according to the pipe demand of the successive branch lines supplying the various population centers. Thus, the changes in diameter take place at the secondary branch lines with the highest consumption levels:

- Branch line to Horcajo de Santiago (CD-1), reduction in pipe diameter from 1,800 mm to 1,600 mm.
- Branch line to Alcázar de San Juan (CD-5), reduction in pipe diameter from 1,600 mm to 1,400 mm.
- Branch line to Puertollano (CD-8), reduction in pipe diameter from 1,400 mm to 800 mm.

The pipeline is designed to carry water by gravity, from the reservoir or ATS canal as far as to its connection with the secondary branch line.



Plan drawing: upstream regulation reservoir.

Upstream regulation reservoir. The Campos del Paraíso dam (Cuenca) is located beside the Tajo-Segura canal. It is an earth-fill dam of the zoned-earth type, with a watertight clay core, measuring 18m high above its foundations and 517m long at the crown. The water volume held at the Maximum Normal Level (NMN) is 5.8 hm³. It has the following main features:

- Spillway, located on the left bank, fixed crest type, with frontal water entry.
- Under drains, running along the right bank spur, under the foundations of the dam core.
- Water collection for supply.
- Water collection from ATS.
- Auscultation and control equipment.

The pipe is equipped with a number of features including flexible automated joints, inner mortar lining and outer varnish lining. It rests on a bed of granular material that favors drainage and prevents floating of the pipe in areas with high water table levels.

The horizontal elbows of the main pipeline consist of cast iron or AISI-304L class stainless steel. Standard elbows are cast iron and the rest are stainless steel. The radius of curvature adopted is three times the pipe diameter. The design was optimized through the use, whenever possible, off a single special part serving the twofold function of an elbow and air vent, thereby minimizing costs, load losses and the complexity of execution.

Solid concrete anchor blocks were placed at all in direction or gradient changes and sectionalizing valves. The elbows are embedded in the concrete anchor blocks. Also worth highlighting are the air vents – air inlets and outlets in the pipes – serving a fourfold purpose: bleeding air, expelling air during pipe filling, air injection during controlled

emptying, and air intake in the event of an emptying of the pipe due to a breakage or improper operation.

To enhance the safety of the hydraulic network, over-velocity valves were installed at the branch junction houses, which automatically shut off in the event of a major leak occurring at any point on the pipeline. This minimizes water losses and consequent damages to adjoining land and infrastructure. In particular, the project features the following valves:

- Three automatically operated DN-1400 PN25 over-velocity valves.
- Three automatically operated DN-1600 PN25 over-velocity valves.
- One automatically operated DN-1800 PN16 over-velocity valve.

Secondary pipeline to Gasset reservoir. At the end of the main pipeline a secondary pipeline carries on for a further 36.2 km with a 800 mm diameter pipe, followed by an 8.8 km tranche of 350 mm diameter pipe.



Anchoring of pipe due to excessive gradient on 1,800mm diameter tranche.



Excavation arrangements for the 1,800 diameter tranche.

Both the main and the secondary pipeline run in a northwest-southeast direction across the provinces of Cuenca, Toledo and Ciudad Real, passing the towns of Campos del Paraíso, Villas Viejas, Saélices, Uclés, Pozorrubio de Santiago, Villamayor de Santiago, Villanueva de Alcardete, Quintanar de la Orden, Miguel Esteban, Campo de Criptana, Alcázar de San Juan, Herencia, Puerto Lápice, Las Labores, Villarrubia de los Ojos, Daimiel, Torralba de Calatrava, Carrión de Calatrava, Fernán Caballero and Malagón.

The design of the secondary pipeline likewise allows the flow of water by gravity, and the same type of pipe was used as on the main pipeline, except on the sunk sections under two roads (CM-4114 and CR-2121) at the 33.450 km and 36.034 km points, respectively. On these sections cast iron pipe with K-9 restrained joints were used to assure the quality of the unions.

The change in diameter from 800 mm to 350 mm takes place at junction house number 11 in Ciudad Real.

Like the main pipeline, this secondary pipeline is equipped with all the necessary types of air vents, valves and outlets ensuring optimal hydraulic operation. In addition, it is fur-

ther equipped with a DN-800 PN40 over-velocity valve.

Connections, branch lines, automation, affected infrastructure and electrical supply. It is worth highlighting the preparation of the various connections with the future branch lines; the unions between the different diameter tranches; the automation and remote operation systems for all the devices on the dam and throughout the pipeline and the affected structures, which basically include a number of crossings with major communication routes, such as the A-3, A-4, and A-42 highways, the AP-36 toll road and high-speed and conventional railwaylines.

As regards electrical supply installations, these include all the junction houses on the upstream regulation dam, power and lighting installations; electrical installations on all the branch junction houses; dam auscultation system, emergency plan and its implementation, control centers, environmental measures and archeological activities, among others.

Lastly, it is worth highlighting the safety and health aspects inherent to every public works project.

Both the main and the secondary pipeline run in a northwest-southeast direction across the provinces of de Cuenca, Toledo and Ciudad Real



Installation of special part on 1.600 mm tranche.

Of all the elements and actions included in the project, it is worth highlighting the following, given their importance for the operation of the system:

- Branch junction houses. A total of 11 structures located on different points along the pipeline. They consist of a vault with concrete walls up to 1.20m thick due to the high pressures withstood in the event of a sudden shutoff of the over-velocity valves. Over the vault stands a house built on site, with an Andalusian tile roof that fully blends in with the landscape.



Secondary branch pipeline to Ortega y Gasset reservoir, 800 mm tranche.

In addition, these houses are equipped with closure devices (motor operated butterfly valves) and relief valves to relieve water hammer pressures in the event of a sudden shutoff of the safety valves due to a network failure. They are also equipped with the necessary fittings for the changes in diameter between the various pipe tranches.

All the structures are equipped with upstream pressure probes and downstream ultrasound flow rate meters, as well as a gantry crane to facilitate the operation of the system. Operations on the safety (over-velocity), bypass and air vent valves must be performed on site, while the rest of the system operation procedures are automated.

- Automated systems. A comprehensive project for the supply of water to a major area like Llanura Manchega, through a newly constructed network of 800 km of pipeline linking more than 60 towns requires a communication infrastructure commensurate with its scope and the

current state of technology. Thus, an optic fiber network was installed with sufficient capacity to absorb any extension, whatever its size, and allowing at any time an increase in the number of variables required to be analyzed.

Two control centers were set up – a main one at the drinking water treatment plant, and a secondary one at the Carras-cosa dam emergency room – which control the equipment and instrumentation of both the dam and the pipeline.

A broadband system was likewise set up for the management of emergency plans at State dams belonging to the Guadiana Water Board. This constitutes a reliable and redundant communications system linking the dam with at least the Civil Defense department, the Government Subdelegate's office and the relevant ministerial department.

The network is likewise linked to the S.A.I.H. (Automated Hydrological Information System) and effectively connected to the upstream general regulation system: the Water Board must have access to real-time data on the flow of water captured from the aqueduct, as well as to all types of water output figures and basic safety data on the the upstream reservoir dam.

Every branch junction house is equipped with the necessary automated systems to enable the operator of the system to centralize all the information and necessary maneuvers at the control centers.

- Archaeological investigations. Neither the original project nor its amendment contemplated – according to the Environmental Impact Assessment – any archaeological investigations on the pipeline route. The assessment report only warned of the proximity of the Segóbriga site and the convenience of having an archeologist on hand to supervise the excavation of the pipe trench.



Main pipeline: land clearing, stocking pipes and material and archaeological prospection campaign.

During the execution of the works and as a result of such supervision, a number of archaeological sites were identified, requiring prior investigation before proceeding with the excavation of the pipeline trench.

Approximately 35 km of the route were affected, preventing the execution of the works without prior archaeological investigation. As a result, some 9 km were subjected to exhaustive investigation.

A preliminary archaeological project was carried out, followed by the excavation itself and the relevant final reports to enable the Department of Culture to decide whether to grant the right of way through the area or, alternatively, require that the pipeline be diverted in order to protect the region's heritage.



Archaeological site (Pozo Sevilla) on pipeline route close to Alcázar de San Juan 1,600 mm tranche.

Particular features of the project for water collection from the Tajo-Segura canal

The execution of a project to collect water from a major canal in service like the ATS faced considerable constraints and challenges. The water collection and lateral spillway construction works were completed within the deadline agreed between the Guadiana and Tagus Water boards, the latter being the body responsible for the operation of the system.

Further challenges arose due to the fact that the pipeline runs in a northeast-southwest direction across the provinces of Cuenca, Toledo and Ciudad Real. This region, known for being the largest plain in the Iberian Peninsula, already has a number of existing major infrastructures, in particu-

lar the CM-310 road from Alcázar de San Juan to Albalate de las Nogueras (Cuenca). Said road, in its section parallel to the 1,800 mm stretch of pipeline in the province of Cuenca, runs along the most suitable corridor for laying this type of water infrastructure.

Hence, the project designers were forced to run the pipe along other areas characterized by abrupt river courses and difficult terrain, as was the case in the vicinity of the

natural course of the Cigüela river. These difficulties were compounded by extremely heavy rainfall in the autumn of 2009 and winter of 2010, which raised the water table. Consequently,

the trench excavation work was affected by these circumstances, especially as regards the stability of the cuttings, requiring the use of lateral timber supports on several trench sections to ensure adequately high safety conditions. The large diameter, weight (up to 8,000 kg/pipe section) and length of the pipe sections involved added to the difficulty of the work.

Nature and logistics of the pipe

Regarding the logistics of the pipe, another essential aspect for a project of this size was the coordination of all the tasks and operations involving the pipe and special components. For the manufacture of the pipe, a range of foundries from all over the world were considered.

It was finally decided to contract it with Xinxing. The pipe was supplied by its plants in China: Handan for the 8m pipe sections, Wuhu for the 6m sections and Changsha for special parts. To assure the quality of the pipes supplied, two accredited Spanish laboratories were commissioned to inspect and monitor the cast pipe sections and special components during their manufacture at the manufacturing facilities of Xinxing Ductile Iron Pipes, CO. TD in Handan, Wuhu and Changsha. Said quality control was extremely intensive and exhaustive.



Unloading pipes.

Initially the pipe sections were carried on conventional ships, but these experienced problems when loading and unloading their cargo. Therefore it was decided to use box ships instead.

Subsequently, in order to minimize any possible damage to the pipes during loading, unloading and ocean transit, it was decided to carry them inside 20 foot (for the 6m pipe sections) and 40 foot (for the 8m pipe sections) containers. To cut down transport costs, the pipes were shipped with a smaller diameter section inside a larger diameter one. Thus, 1,600 mm pipe sections were supplied inside 1,800 mm diameter pipes, and 1,400 mm pipes inside 1,600 mm diameter pipes.

The Spanish ports used were those of Sagunto, Cartagena and Valencia, from where two specialist firms carried them to their final destination. The intensity of transport to the work sites reached a peak of up to 80 trucks per day.

The timing of the felling and clearing works was planned so that the pipe stocking areas would be ready on time, thus avoiding unnecessary transport. The problem of pipeline sections stopped due to archaeological discoveries was solved by establishing stocking areas outside the pipeline route itself.

Pressure testing of the cast pipe sections proved the most difficult part of all the work carried out in the overall execution of the water transfer pipeline project, since the high pressures (of the order of 35 atmospheres) and diameters (up to 1800 mm) involved generated thrust loads of up to 750 Tn.

Hence, a specific pressure testing structure had to be calculated, capable of withstanding such loads, that could be used for all the tests, regardless of the diameters and pressures involved. A specialist metal structure and boiler forging manufacturer was charged with building a system consisting of a reinforced plug flange and a reinforced support structure made up by four latticework gantries built with welded HEB-200 and HEM-180 sections. A plug flange

of suitable size was used for each pipe diameter to be tested, while the same support structure was used for all pipe diameters.

Said structure was connected to the foundation by means of spreader plates with M-40 corrugated rods threaded at the end and a minimum length of 500mm embedded into the concrete of the foundation slab. The structure calcula-

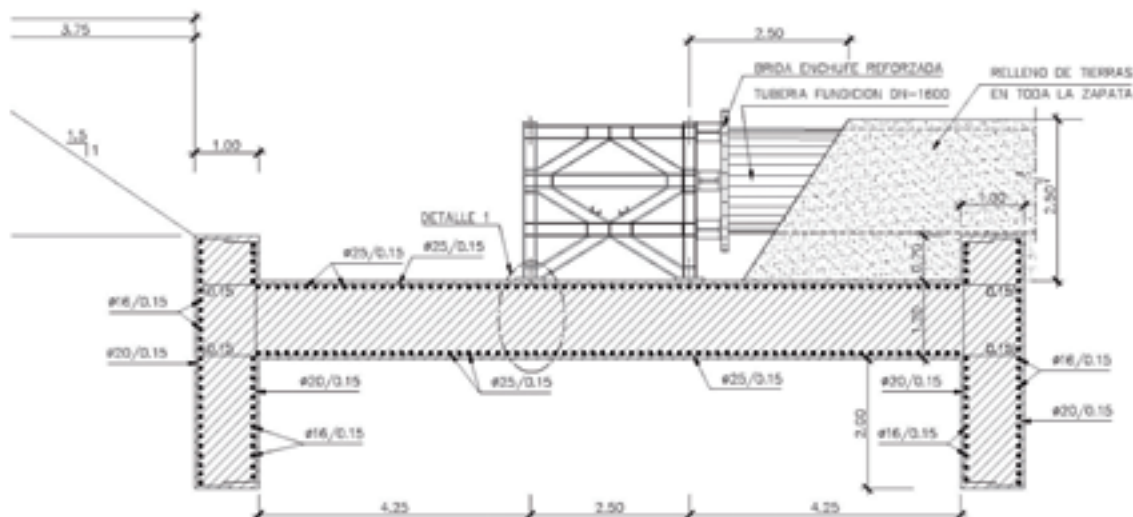


Diagram of the pressure testing structure-foundation assembly.

tion was performed using the Tricalc 3-dimensional structure spatial calculation software.

Once the structure and plug flanges had been calculated, OHL's technical department in Madrid designed the anchor plates and foundation slabs for the different pipe diameters and pressures.

By way of an example, one of the foundations designed consisted of a reinforced concrete pad 13 m long, 9 m wide and 1.20 m thick, and a reaction wall, at either end, measuring 3.90 m in height and 1.20 m thick, back-filled with earth to provide the necessary passive thrust resistance.

This symmetrical arrangement allows the pressure tests to be carried out in either direction (therefore, for adjacent sections only the plug flange position has to be changed) and also provides the passive thrust resistance.

Once the challenge of designing the pressure testing structures had been overcome, all the pressure tests required were successfully carried out. Initially relatively short pipeline sections were tested, of approximately 1,000m, and subsequently longer sections were tested.

This is a clear example of how the preservation of the cultural and historical heritage can be combined with a major civilworks infrastructure project

Archaeological sites

All the works were carried out rigorously following the established protocols for environmental and cultural heritage conservation. Special emphasis was made on the latter aspect given the proximity of the project works to the Segóbriga Roman archeological site in the municipality of Saélices (Cuenca). From the commencement of the works, intensive surveillance was carried out in this regard and the archaeological activities on the sites, numbering

around 30, were performed in an exemplary manner, with a view to broadening the knowledge of the historical processes undergone by the region from prehistoric to modern times. This activity doubtless constitutes a clear example how preservation of the cultural and historic heritage can be combined with the execution of a major civil works infrastructure project, and evidences the interest shown by Grupo OHL in contributing to the development of the Castilla-La Mancha region and the preservation of its origins.



Madrigueras III archaeological site uncovered beside branch junction house. Horcajo, 1,800 mm pipe tranche.



Madrigueras II site uncovered in 1,800 mm pipe trench, beside upstream dam.

Main construction units		
Description of unit	Measurement	Unit
Ductile cast iron pipe 1,800 mm diameter. k-9, elastic joint	30.512,00	ml
Ductile cast iron pipe 1,600 mm diameter. k-9, elastic joint	53.574,00	ml
Ductile cast iron pipe 1,400 mm diameter 1.400 mm. k-9, elastic joint	34.048,00	ml
Ductile cast iron pipe 800 mm diameter. k-9, elastic joint	36.214,00	ml
Ductile cast iron pipe 350 mm diameter. k-9, elastic joint	8.843,00	ml
Large diameter stainless pipe for reservoir collection and outlets	211,00	ml
Carbon steel pipe for outer jacket of road and railway crossings	854,00	ml
Duplex stainless steel pipe for road and railways crossings	105,00	ml
Stainless steel parts and sections	259.606,00	kg
Carbon steel flanges	97.903,00	kg
Polyethylene tubes (2) for optic fiber	162.786,00	ml
PVC pipe of various diameters	7.639,00	ml
Polyethylene pipe sleeve	56.631,00	ml
Felling and land clearing	6.020.169,00	m ²
Open air excavation	330.196,00	m ³
Trench excavation (all types of terrain)	3.770.711,00	m ³
Trench fill-up with excavated material	2.854.147,00	m ³
Fill-up with granular material	539.551,00	m ³
Clay in dam inner core and reservoir bed lining	764.573,00	m ³
Breakwater	21.730,00	m ³
Filters in body of dam	18.174,00	m ³
Drains in body of dam	11.465,00	m ³
Structural concrete	94.204,00	m ³
Passive reinforcement steel	2.719.910,00	kg
Tarmac	596,00	tm
Aggregates	48.673,00	m ³
Replanting	59.095,00	ud
Manual archaeological excavation	46.919,00	m ²

Elsan bituminous mixture studies, quality control
and research laboratory



Quality control, studies and trials on asphalts and other building materials are carried out in its facilities

Elsan bituminous mixture studies, quality control and research laboratory

Asfaltos y Construcciones Elsan's quality control and research laboratory is one of Spain's leading facilities in the field of bituminous mixtures. It operates a quality and environmental management system based on the ISO 9001 and 14001 standards, covering the performance of technical assistance activities, soil testing and quality control of the materials used in road construction. Its infrastructure meets the specifications of European standards UNE-EN 12697, regarding test methods for hot bituminous mixtures, and UNE-EN 13108, regarding bituminous mixtures and material properties.

Asfaltos y Construcciones Elsan's quality control and research laboratory is located at the premises of this Grupo OHL subsidiary in Arganda del Rey (Madrid) since 1990, together with the company's bituminous mixture manufacturing plant and machine depot.

The laboratory, belonging to the Deputy Directorate of Technology, carries out a number of activities related to road surface construction quality.

It is considered one of the leading laboratories in the field of bituminous mixtures Spain. Such a position has led to the constant presence of its staff in technical forums, working groups and national and international conferences within this sector.

Asfaltos y Construcciones Elsan's quality control and research laboratory is a leading facility in the field of bituminous mixtures in Spain

The laboratory is equipped with the testing apparatus and machinery required to perform most of the procedures described by the currently effective European standards, as regards both the constituent materials and the finished products: bituminous mixtures, materials treated with hydraulic conglomerants and soils, among others.

This facility also carries out different types of activities: quality control of the manufacturing and application facilities on Elsan work sites, technical assistance to Grupo OHL member companies, and participation in research and development projects for new products with different features requested by clients.



Types of materials and products used on road surfaces

Bituminous binders

Soils

Granular materials

Earth floors stabilized at the plant and on site

Cement treated materials: gravel and cement soil

Cold set micro-agglomerate and bituminous slurries

Cold bituminous mixtures

Hot bituminous mixtures: bituminous concrete and bituminous mixtures for rumble strips and draining wearing course

SMA-type (*Stone Mastic Asphalt*) hot bituminous mixtures

On site recycling of bituminous layers with emulsion

On site recycling of bituminous layers with cement

Hot recycling of bituminous layers at plant



Rigidity Test.



Bonder incinerating equipment.



Roller compactor.



Fatigue equipment.

Quality and environmental management system

The Elsan laboratory has a certified quality and environmental management system in accordance with the ISO 9001 and 14001 standards, covering the provision of technical assistance and laboratory services including soil testing and quality control of materials used in road construction: aggregates, bituminous mixtures and constituent materials, among others.

In addition, the laboratory carries out at the company's two hot bituminous mixture manufacturing facilities in Valencia and Madrid the on-site production control specified as a requisite condition for maintaining the CE Marking, a mandatory requirement for the marketing of its products in the Spanish and EU markets. The CE Marking indicates that a product complies with all the applicable UE legislation.

Tests in accordance with UNE-EN 12697 standard

Indirect traction resistance test

Wear test

Fatigue test: four point prismatic samples

Compacting of test samples using different procedures: impacting compactor, rotating compactor, vibrating compactor, and plate compactor

Bonder content incineration test

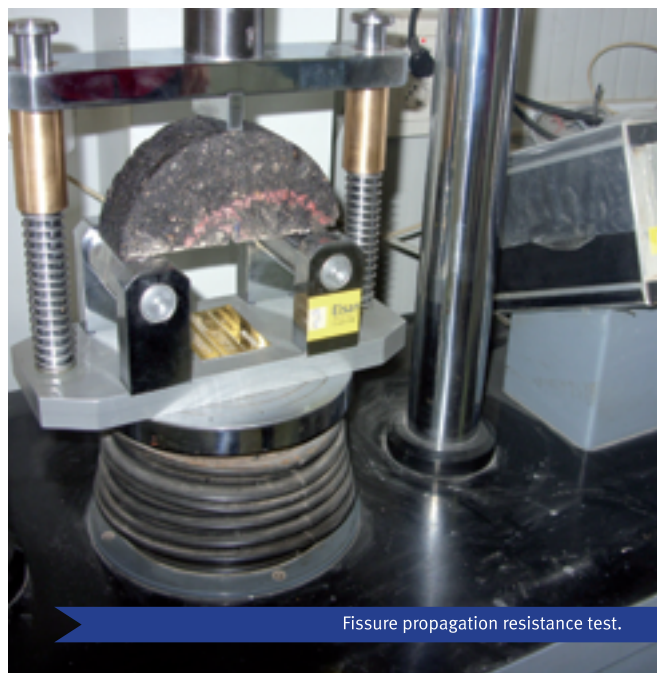
Fuel resistance test

Fissure propagation resistance test

As a result of the harmonization of European standards, the test methods and material properties have changed in recent years, calling for an adaptation of the laboratory equipment and staff. Moreover, the machinery used by the facility is in compliance with the specifications of European standards UNE-EN 12697, regarding hot bituminous mixture test methods, and UNE-EN 13108, regarding bituminous mixtures and material properties.

The above task involves monitoring the characteristics of the materials and of the various manufacturing products, verifying compliance with all the properties specified in their labeling and the specifications required by clients.

The laboratory also provides technical support in the design of the various types of bituminous mixtures (type



Technical assistance

One of the main activities of the laboratory is providing technical support to the various departments of Elsan and to Grupo OHL companies, involving either one-off activities or the performance of ongoing, scheduled projects

testing) or other materials, taking into account client specifications, necessary adjustments to the manufacturing facilities and the control of the pavement surface characteristics, including macrotexture and skid resistance.

Collaboration in R&D&I projects

The research carried out leads to the development of new product types and different technologies which in some cases can provide interesting solutions, from a technical and financial standpoint, for the various types of work carried out in the construction industry.

Thanks to the Elsan laboratory's participation in research projects, it now possesses testing equipment to determine a wide range of material and product properties, especially bituminous ones, with useful applications to the construction of the different road layers.

The laboratory has engaged in collaboration with a great number of universities, including the Civil Engineering departments of Universidad Politécnica de Madrid (UPM) and Universidad Politécnica de Cataluña, and the Civil Engineering Applied Acoustics Laboratory of Universidad de Castilla-La Mancha (UCLM), as well as the Centre for Studies and Experimentation (CEDEX).

The Elsan laboratory has also taken part in working groups whose members included some of Spain's most prestigious technical experts.

These investigations have led to the development of new technologies (especially in bituminous materials) applicable to the construction of road layers.

The most noteworthy projects in which Elsan has participated include:

- *Fénix Project*: safer and more sustainable roads. 2007-2010. Consortium of 13 Spanish companies and leading research centers and universities. Elsan was the leader of *Task 9: Safety and comfort on roads*, involving the performance of studies on quieter road surfaces, anti-ice bituminous mixtures, improvement of the skid resistance coefficient on aggregates, micro-agglomerates for very thin layers, and nanomaterials active in the reduction of combustion gases (www.proyctofenix.es).

The laboratory provides technical advice on the design of different types of bituminous mixtures and other materials

Technical assistance provided to Grupo OHL on some of the most significant projects

Algiers second south beltway (2007-2011)	Analytical study for the change of the roadbed package performed by Elsan's Deputy Directorate of Test Technology and raw materials studies Design of the working formulae for the various bituminous mixtures in accordance with the Algerian-French standard specifications Technical support during project execution
UTE Apron Sur temporary joint venture: South Platform-Phase II. Barcelona Airport	Study of alternative solutions to specific problems on fuel-resistant pavements
Road crossing San Pedro de Alcántara, Málaga	Study of alternative solutions to specific problems on porous pavements with high drainage coefficient
Ponzano-Velilla tranche of A-22 highway, Huesca. (2008-2010)	Adjustment of facilities and collaboration in quality control during the execution of the works
A-1 highway, construction of alternative route at El Molar (2008-2009)	Adjustment of facilities and collaboration in quality control during the execution of the works
Maintenance and operation of A-2 highway between Km 5.9 and Km 62.0 . Tranche between Madrid and Radial 2 toll road	Quality control, for A-2 concession, of the different construction units: soils, treated materials, granular materials and bituminous mixtures
Overlay of 12L-30R runway at Zaragoza Airport Overlay of A Coruña Airport runway	Technical support and study of materials used in the various works
Refurbishing of the Juan Carlos I Royal dock to hold sports events. E 07/25	Technical support and study of materials used in the various works
N340 road rerouting at Albaida MF	Technical support and study of materials used in the various works



- SMA Project, Sustainable and Environment-friendly mixtures of the UNE-EN 13108-5 (2010-2013) Standard. The intended aims consisted in providing a specifications proposal for Spain for SMA type mixtures as described in the UNE-EN 13108-5 Standard, as well as developing various technologies for manufacturing at lower temperatures, with recycled materials and OUT (out of use tires) with a high hollow and binder content (www.proyectosma.eu).
- Development of special mortar for road slab application. 2009-2011. Project developed by OHL with specific resistance, fluidity, expansion and occluded air characteristics, among others.

Sustainability commitment

The commitment to sustainability and environmental conservation is one of the principles of conduct of Grupo OHL and its subsidiaries. With regard to the manufacture of bituminous mixtures it is worth highlighting several techniques allowing the reduction of particle emissions into the atmosphere or the reuse of elements regarded as waste.

The commitment to sustainability and environmental conservation is one of the principles of conduct of Grupo OHL

Novel products have been developed at the laboratory by using new raw materials, new manufacturing technologies or the provision of advantageous solutions to meet the required property specifications.

Some of these materials are:

- Use of OUT in different proportions in the manufacture of bituminous mixtures.
- Use of recycled material from the scraping of bituminous pavements in the manufacture of bituminous mixtures; or the use of recycled concrete materials such as granular sub-bases.
- Manufacture of semi-hot bituminous mixtures at lower temperatures (30-40^o C reduction in manufacturing temperature) with similar characteristics to hot mixtures.
- Manufacture of cold bituminous mixtures using asphalt emulsions.
- Study of bituminous materials with higher fuel resistance.

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Mayakoba consolidates its international prestige

The Mayakoba tourism complex, developed by OHL Desarrollos in the Riviera Maya, in the Mexican state of Quintana Roo, continues to receive international recognition for its commitment to balancing tourism development with social welfare and environmental conservation, a pioneering experience started in 1998.

Located at a distance of 8 km from Playa del Carmen, on the central coastal fringe of the Mexican Caribbean, it covers 649.3 hectares of high ecological value, containing several fragile ecosystems with a great diversity of flora and fauna that Grupo OHL has always taken into account since the initial planning stages.

Mayakoba, an international showcase of sustainability

For the design of the facilities, OHL set up a multidisciplinary team whose combined experience and know-how allowed the definition of an ecological profile serving as the basis to design a tourism complex offering a distinct alternative to the *all-inclusive* formula. It currently comprises three exclusive hotels, Fairmont, Rosewood and Banyan Tree, as well as the El Camaleón golf course, venue of the *Mayakoba Golf Classic* event since 2007.

The project also included the recovery of the mangrove forest, involving the design and construction of a lake system with artificial navigable canals covering a total surface of 25 ha and a distance of 13 km, which enjoys the best forest structure and environmental quality in the entire Mexican Riviera Maya.

The recovery of this and other ecosystems has positioned Mayakoba as a showcase of sustainability at the interna-



Mayakoba. Riviera Mexicana. Mexico

tional level, currently providing a natural habitat for some 200 bird, fish, reptile, crustacean and mollusk species, compared with only 70 prior to these environmental improvements.

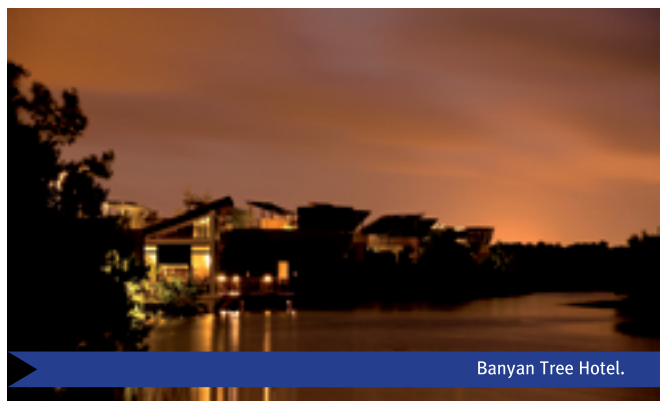
International recognition

The combination of sustainability, environmental protection and a tourism offering with the highest levels of luxury and exclusivity have earned Mayakoba widespread international recognition. Proof of this is the *Environmental Quality Tourism Certification* awarded in 2013 by Mexico's Federal Attorneyship for Environmental Protection (PROFEPA), which recognizes the positive impact that tourism can have on the environment. It has also received the *Ulysses* award in the business innovation category, granted by the United Nations World Tourism Organization, and the *Sustainable Standard-Setter Award*, granted by Rainforest Alliance, a Global Sustainable Tourism Council (GSTC) member, for compliance with sustainable tourism standards. They are the highest awards granted by these prestigious organizations and institutions.



Fairmont Hotel

The outstanding quality of the Fairmont Hotel, which in April 2013 extended its offering with the opening of the Fairmont Heritage Place Mayakoba complex comprising 30 luxury residences, has been endorsed for five consecutive years since 2007 with the AAA *Five Diamond Award*, the highest rating granted by the United States' prestigious American Automobile Association (AAA), awarded every year to less than 0,3 % of the more than 50.000 hotels included in its *ranking*. The hotel is also featured in *The Gold List 2012*, published by *Condé Nast Traveler* magazine, while *Trip Advisor* includes it in its *The Top Luxury Hotels in México 2012 list*.



Banyan Tree Hotel.

The exclusive Rosewood Mayakoba has been pronounced the best *spa* hotel and *resort* in Mexico by the readers of *Travel & Leisure* magazine in its *World's Best Awards 2013*. *Condé Nast Traveler* included it in the 2012 edition of *The Gold List*; the *Gayot* guide featured it as one of the world's *top 20 romantic hotels in 2012*; it was among *MDC Magazine's* Top 20 Small Luxury Hotels for Meetings in México, both in 2011 and 2012, and it received the *World Travel Award 2011* as one of the best holiday resorts in Mexico and Central America.

The Banyan Tree Mayakoba hotel *spa* has also won plaudits

from the publications specializing in travel. *Condé Nast Traveler USA* added it to *The Hot List* in 2010, and it received the *American Property Award 2008* granted by American Property Awards in association with *The New York Times (CNBC)*, which rewards excellence among the world's best tourism resorts.

El Camaleón, a landmark in the world of golf

Designed in 2005 by golf legend Greg Norman, El Camaleón is a 7,039 yard golf course straddling three different environments: tropical forest, dense mangrove and sandy sea-side areas. Its design also includes a cenote –natural water-filled cavern typical in the region– in the heart of the first *fairway*, and the holes are separated by limestone canals.

Since 2007, El Camaleón hosts the *Mayakoba Golf Classic* – currently known as the *OHL Classic at Mayakoba*– forming part of the PGA TOUR tournament calendar. This event distinguishes itself by being the only one in the circuit held in México. In its various editions the tournament has gathered world class players including Fred Funk, John Daly, José María Olazabal, Mark Wilson, Jay Burlison, Johnson Wagner, John Huh and Greg Norman, among others.

Commitment to the community

Grupo OHL, faithful to its commitment to community development and environmental conservation, has kept a distance of 500 meters between the structures in Mayakoba and the beach.

Moreover, the holiday complex constitutes a source of wealth in the area, generating an average of 1,700 direct jobs and 3,300 indirect jobs every year, as well as a number of social initiatives promoting the manufacture and sale of local products, the upgrading of facilities at a primary school located in the area and the cleaning of beaches.



El Camaleón golf club.

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