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Start of manufacture of PCCPs (Pre-stressed Concrete Cylinder Pipes) for long-term water supplies in the Gulf of Oman

Future-oriented water management is one of the most strategically significant economic issues in the Gulf state of Oman. It includes, on the one hand, the creation of infrastructure for overcoming a few concentrated intense rain events. The growing requirements with regard to the daily mobility of people and commodities do not permit public life to come to a standstill several times a year as a result of heavy rainfall. On the other hand, in a country which is extremely exposed to the elements with growing conurbations such as Oman, providing reliable drinking water supplies constitutes a financially, technically and also politically demanding task. The cost-effectiveness of concrete pressure pipes for drinking water transportation compared, for example, to steel or cast-iron pipes was crucial for making an investment in the completely new manufacture of concrete pressure pipes prepared in an exemplary manner, as well as a legislative act. In addition to conventional concrete pipes for surface water management, concrete pressure pipes will now also be manufactured in a new factory with an operating pressure of up to 25 bar for future drinking water projects.

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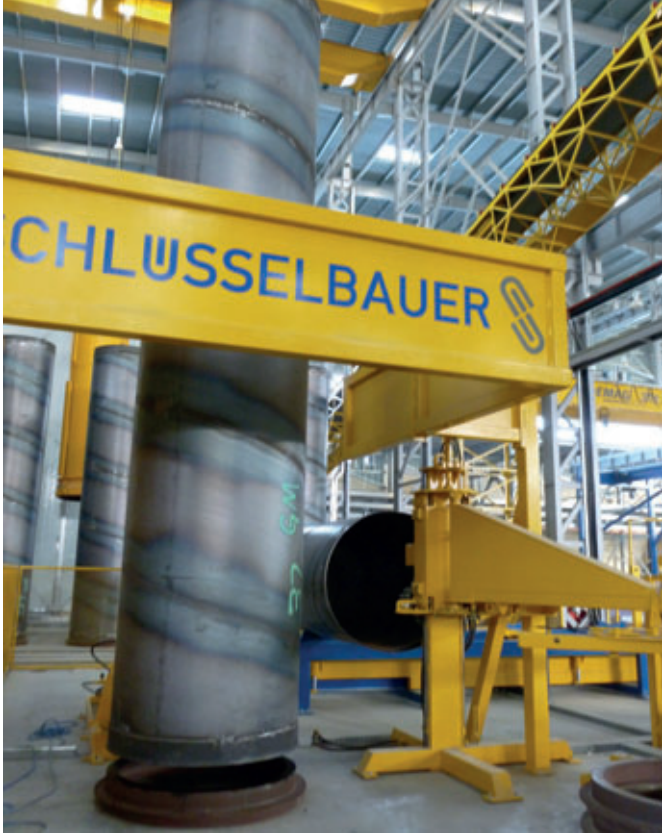
As part of this long term-oriented, strategic planning, it was decided to commence manufacture of concrete pipes at the company Amiantit domiciled in the Sultanate of Oman in addition to the already established pipe construction products after the ban on asbestos fibre cement pipes. Concrete pressure pipes will be manufactured first and foremost, in addition to conventional concrete pre-cast components such as reinforced concrete pipes and box - culverts. Compared to steel pipes, for example, concrete pressure pipes are characterised by reduced material costs with simultaneously higher corrosion resistance. In addition, tight joints are simpler to attain with concrete pressure pipes. With the analysis and determination of the product concept and the specification of the necessary manufacturing technology an international team of advisors was commissioned under the leadership of Mr. John Munro, owner of Munro Ltd. headquartered in Ontario, Canada. Established products and available procedures were examined on a global scale in order to ultimately be able to make a certain awarding decision. After the recommendation for selection of equipping companies which would facilitate the most cost-effective manufacture in accordance with the specific requirements, the experts at Munro are continuing to assist the manufacturer in the commissioning of the extensive manufacturing technology and the commencement of production.

The segment of concrete pre-cast component manufacture is new for the manufacturer. To date, they have longstanding experience with the materials PVC, PE and GRP and the now prohibited asbestos fibre cement pipes. In the newly established company Amiantit Oman Concrete Products LLC concrete pipes are now produced for

In addition to concrete pressure pipes, reinforced concrete pipes of nominal widths DN300 to DN1800 and concrete jacking pipes are manufactured.

Amiantit Oman, founded in 1974, is one of the largest manufacturing companies of the Gulf state.

For the manufacture of the sheet steel core used for the impermeability of the concrete pressure pipe, a cylinder is automatically welded and cut to length and tested according to the pipe construction length.

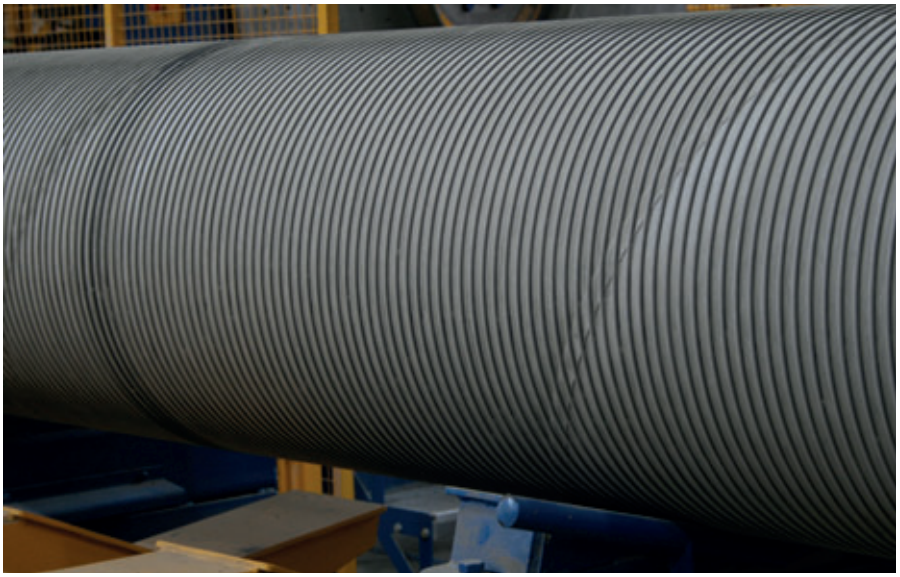


The sheet steel cylinder is automatically placed on a joint and concreted after the equipping of the mould for the manufacture of the internal lining of earth-moist concrete.

gravity sewers in a first stage in the nominal widths DN 300 to DN 1800 and box - culverts of 2000 x 1500 mm to 2500 x 2500 mm. The box - culverts and the large DN 1200 to DN 1800 mm pipes are manufactured on a Schluesselbauer Exact XL vertical dry casting machine, the smaller pipe dimensions are manufactured on a packerhead machine. This subdivision into two manufacturing processes is justified by the fact that this machine type was needed for the inner lining of steel cylinders for the production of concrete pressure pipes – the subsequently described second stage in the set-up of concrete pipe manufacture. In the past, related manufacturing procedures were analysed to develop a concept for the manufacture of concrete pressure pipes. The multitude of methods such as one-, two- or three-layer manufacturing procedures, ring and/or longitudinal pre-stressing, steel pipe connections with a rolling or sliding rubber connection and the resulting different product characteristics led to the decisionmakers establishing a team of advisors under the coordination of a successful manufacturer of concrete pressure pipes. After clarification of pipe construction requirements in the Sultanate of Oman and comparison with available manufacturing methods, a two-layer concreted pipe with a sheet steel core and ring pre-stressing reinforcement to be provided with an outer protective layer created from shot - crete was selected. The pressure pipes will be manufactured in the nominal diameters DN 600, 800, 1000, 1200 and 1400mm in accor-

The steel wire required for pre-stressing is also brought to the plant in coils where it is processed with a wrapping speed of up to 6 m/s.

The pre-stressing machine developed by Schluesselbauer works at a wrapping speed of up to 6 m/s.



In accordance with the necessary operating pressure of the concrete pressure pipes, wire thickness, pre-stressing and the pitch of the wrapping are determined.

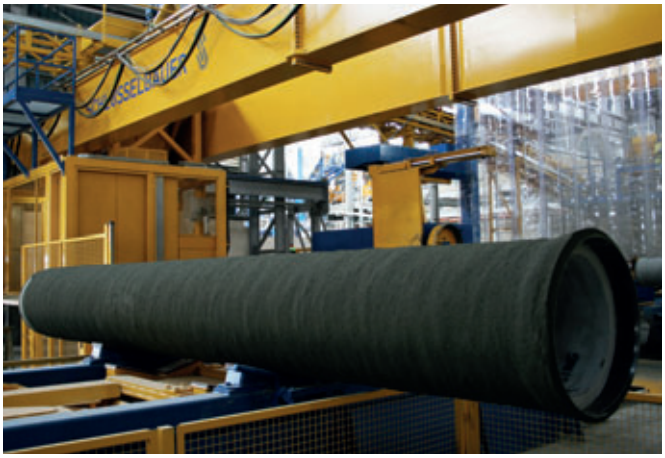
In the final manufacturing step, an external protective layer is applied to the pipe with spun concrete.

dance with the AWWA C301 and C303 standards.

The machines for the manufacture of the steel cylinders, steel end rings and the wire pre-stressing needed to be designed with appropriate flexibility. And the entire handling also needed to be conceived in an appropriately flexible manner in order to be able to execute all critical manipulation tasks in a fully automated manner and with the least expense for conversion works.

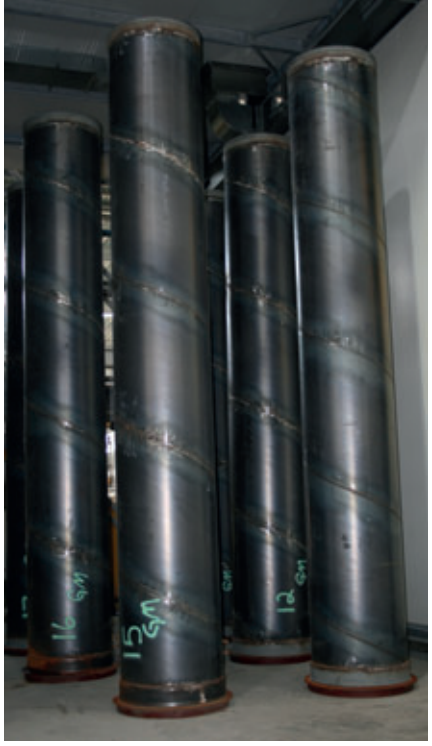
Concrete pressure pipes have proven themselves in their use in drinking water pipes for decades. An inspection of a pressure pipe test stretch in Baden-Württemberg, Germany with a total of four different types of DN600 concrete pressure pipes at a pressure of 10 bar showed that the pipes were in an impeccable state after continuous operation over several decades. This test stretch was constructed in 1954 to 1956 in a geodetically highly stressed section of piping in order to acquire insights for the subsequent construction of a long-distance water pipeline. Over half a century later this pipe would now be utilised for energy generation due to its gradient and the pressure would be increased to up to 13 bar. Four types of pressure pipe available at the time were originally installed. Three of the pipes affected by the intended change in use were tested at a test pressure of 14 bar. After the first positive insight that the pipes were still in a very good operational state came the second positive insight. The tested pipes also easily withstood the increased pressure. Due to these insights, it can also easily be stated in relation to the concrete pressure pipe principle in the 21st century too to thus create structures with a lifespan of over hundred years.

It is primarily the manufacturing technology of the concrete pressure pipe principle which has changed fundamentally since the previously described project. Individual working steps were modernised, the entire production process intensely automated and individual pipe components can now

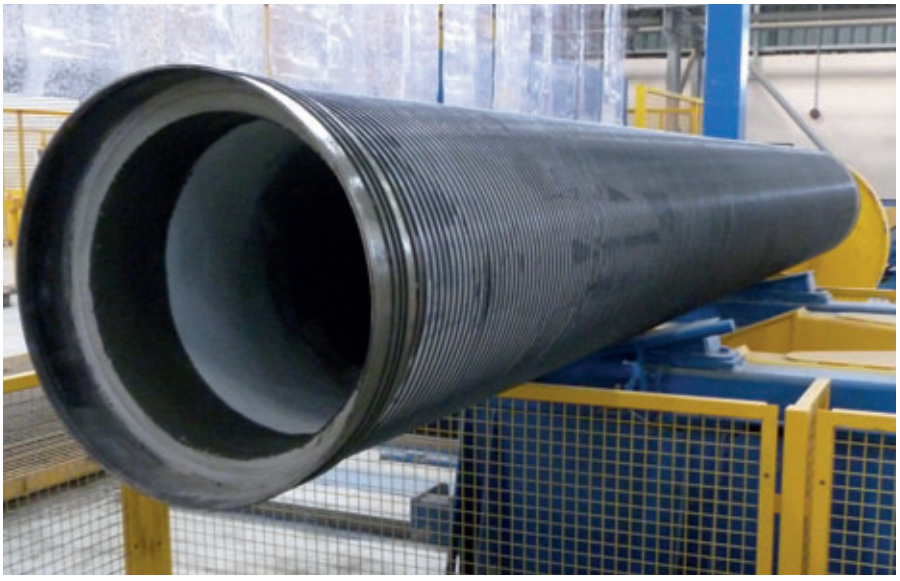


Concrete pressure pipes can be manufactured with different joinings. In the specific project, joints and spigot ends are moulded with steel end rings.

The high degree of automation of the entire plant makes a considerable contribution to the protection of workers and products. Thus, cycle times can be optimised and the reject rate minimised.



Steel cylinders lined with concrete generally harden in kilns in one day. Completion then follows with application of the pre-tensioned wire and the external coating.



A range of fully automated manipulators move the semi-finished concrete pressure pipes through the production plant. The picture illustrates an insight into the concrete lining of the concrete pressure pipe.

be manufactured and processed more quickly and precisely. The integration of the pre-stressing in particular frequently constituted a bottleneck process in series manufacture in the past. With a processing speed of 6 m/s the pre-stressed wire is now integrated so rapidly with state-of-the-art technology that upstream and downstream processes are no longer delayed as a result. However, the basic concept of pressure pipe manufacture has remained almost the same and encompasses three fundamental areas: steel cylinder manufacture, wire pre-stressing and coating in concrete. Added to this in modern concrete pressure pipe manufacture is the manipulation or handling of individual components, semi-finished components and finally the end product.

In steel cylinder manufacture, solid steel end rings which will subsequently form the joints of the finished pipes must be manufactured on the one hand. Hot rolled steel profiles are bent into rings, welded and stretched for this purpose. The steel cylinders of the pipes are welded from sheet steel in different wall thicknesses by a fully automatic helicoidal welding machine dependent on the operating pressure of the pipes.

At Amiantit Oman Concrete Products LLC sheet steel of the wall thicknesses 1.5 to 6.5 mm can be processed to approximately 6 m long cylinders. The maximum weight of the steel coil to be processed is 20 t. After being cut to length, the steel end rings are welded onto the steel cylinders. The impermeability of all steel cylinders is then tested completely. A water pressure test taking place over a period of several minutes at a test pressure of 4 bar recognises the slightest leakages which can be repaired if necessary in a user-friendly manner directly at the testing facility. In contrast to old machines, it is no longer necessary to remove the steel cylinders from the test station. After the quality test has been successfully completed, the cylinder is ready for internal lining with concrete.

The concrete encasement of pressure pipes can be conceived in just as diverse a manner as the types of concrete pressure pipes. Either earth-moist concrete or cast concrete can be used for the simple concrete lining of Lined Cylinder Pipes (LCP). For multiple concrete coating - internally and externally – such as necessary for Embedded Cylinder Pipes (ECP) – both concrete encasement procedures can be combined or the entire pipe is manufactured with cast concrete.

An external protective layer, known as coating, is typically applied with shot - crete. In specific cases, it was initially decided due to the required pipe nominal widths and the desired greater productivity only to manufacture Lined Cylinder Pipes and to use earth-moist concrete for the internal lining of the steel cylinders. After the hardening of the internal lining in curing chambers the concrete steel cylinders are ready for application of the pre-stressed winding wire.

A high-speed pre-stressing machine as the core element of efficient concrete pressure pipe manufacture

A wire pre-stressing machine developed by Schluesselbauer, the technology partner of Amiantit Oman Concrete Products LLC, now provides the concrete steel cylinders with wire radial pre-stressing externally, after a cement-water based primer has been applied to the cylinder. The pre-stressing force possible for this type of machine is more than double the pre-stressing force of 20 kN currently required in this factory. For the manufacturer this means flexibility in case projects with increased requirements are operated in future. Furthermore, increased requirements can also be fulfilled by multiple wrapping with prestressing wire. However, this pre-stressing machine is predominantly characterised by its processing speed. Up to 6 m of pre-stressing wire is wrapped on the concrete lined steel cylinder per second in a defined pitch.

In addition to these three core elements of concrete pressure pipe manufacture, this new factory is predominantly characterised by its high degree of process automation. There is not currently an acute shortage of workforce on site. In the efficient manufacture of concrete pressure pipes in particular, the use of manual activities must be

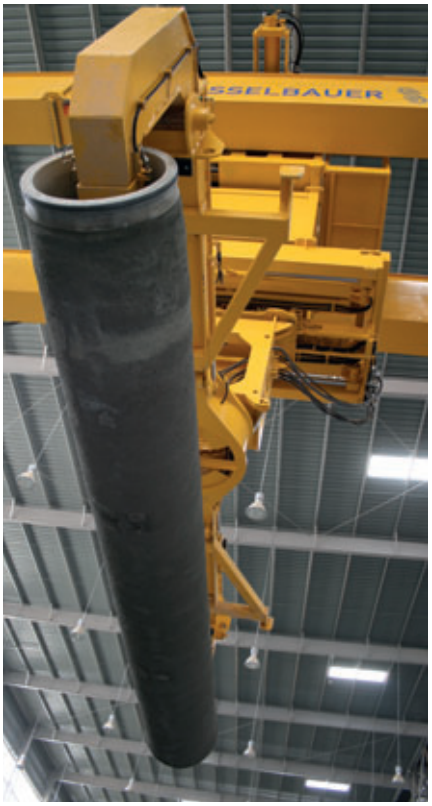
reduced to those areas in which, on the one hand, people are guaranteed not to be placed in danger and in which, on the other hand, even the high-quality products cannot be impaired by human error. A risk factor for workers compared to conventional manufacturing companies results from the dimensions and masses which are moved here. Even the semi-finished components such as steel cylinders or concrete steel cylinders demonstrate considerable masses and in this case a construction length of approximately 6 m which can only be safely manoeuvred by machines. Intelligent automation must contribute here to the fact that industrial safety is not called into question in any phase by partially or fully automated handling and damage to the product is prevented.

The main risk factor for the material is the human being. With every working step, the value of the pipe workpiece increases until it is ready for installation. Schluesselbauer has taken fully into consideration the requirements of the manufacturer in this regard with an intelligent configuration of individual processes and a series of automatic handling systems. The indoor overhead crane is used with special load lifting members for handling the raw materials and steel cylinders. The worker still has high levels of autonomy here. The equipping of the mould for the lining of the steel cylinders with concrete, the offbear of the mould and the placement of the lined steel cylinder into and removal from storage in the curing chambers are also performed with the remote controlled overhead crane. In order that the subsequent working steps are also fully automated and human error can be almost completely eliminated, a number of fully automated manipulators have been installed. They place the lined steel cylinders in the correct position for wrapping with prestressing wire, move the semi-finished pipe on to external coating – and then to handover to the Transexact robotic crane. This transports the completed concrete pressure pipe to the final curing chambers and then to the transfer belt for dispatch to the external storage area. Furthermore, the automatic crane closes and opens the covers of the curing chambers.

In addition to the technology partner Schluesselbauer which, as well as the complete handling equipment, was also responsible for the helicoidal welding machine for the steel cylinder manufacture and testing, for the pre-stressed wire wrapping and the coating and for the production plant for the manufacture of large pipes and box culverts, a series of further reputable plant manufacturers were involved in this project. Thus, for example, Putzmeister supplied a concrete pump for the production of individual custom built wetcast precast structures or components produced in series such as road barriers. The machines for the manufacture of the cage reinforcement for conventional concrete pipes were commissioned at MBK Maschinenbau and the entire concrete batching and conveying technology was supplied by Skako. In addition to the bucket conveyors, a total of three mixers each with a volume of 2.5 m^3 were commissioned which supply the entire concrete required at all production machines. For the optimum utilisation of the spacious manufacturing halls, Demag installed a series of indoor overhead cranes with lifting capacities from 5 to 50 t.

A summary could give the impression that the high degree of automation in product handling was solely based on the outlined safety aspects and not on cost pressure, especially with regard to staffing. In this regard it must be specified that a staff shortage is not anticipated in the foreseeable future, first and foremost due to the high number of available migrant workers in Oman. Such manufacture would be under cost pressure nevertheless if damage constantly arose to semi-finished products or end products due to manual interventions and human error. A rejected pipe would destroy an irrevocable income stream and would also incur costs for professional reprocessing. Sufficient attention was also paid to this aspect in this automation concept. The result is a production facility for lined concrete pressure pipes which is globally unique in the implemented form and in its efficiency.

Amiantit Oman was founded in 1974 and now numbers among the largest manufacturing companies of the country with a broad range of products. Amiantit Oman employs approximately 90 staff, roughly 80 of whom work at Amiantit Oman Concrete Products LLC. The company harks back to a joint venture of the largest industrial groups in the Sultanate of Oman, the Omzest group, the Suhail Bahwan Group and the Saud Bahwan Group. Over 75 companies are integrated into the Omzest Group currently in full or part possession, approximately two thirds of the turnover is generated in manufacturing companies. The Suhail Bahwan Group comprises more than 40 companies and in the Saud Bahwan Group among others products of numerous reputable vehicle manufacturers such as Ford, Toyota or MAN are marketed. In addition to the Amiantit Oman product range, which is primarily focused on the construction sector, the most diverse of services can be found in the group of companies as a whole. Consequently, almost the entire population of the country is integrated into the value-added process.



The Schluesselbauer Transexact automatic crane transports the finished products into the hardening chambers and then to the delivery conveyor belt. It also operates the chamber covers.

FURTHER INFORMATION

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