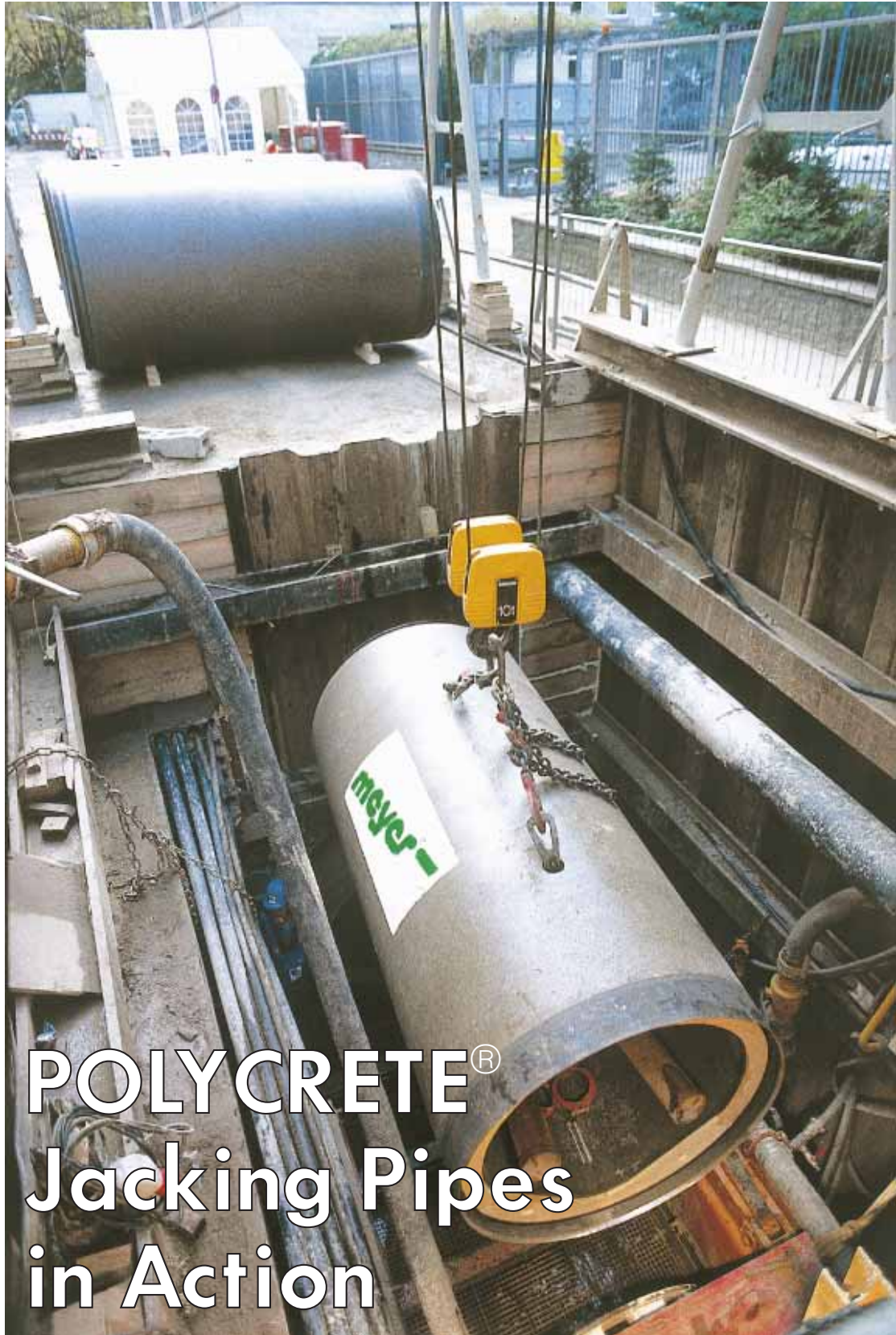


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POLYCRETE[®]
Jacking Pipes
in Action

meyer[®]

FREMONT SEWER REPLACEMENT

A recent sewer project in Fremont, California, U.S.A. comprised the installation and rehabilitation of over 10,225 ft of 12 in and 18 in i.d. pipeline. Client for the project was the Union Sanitary District, a public agency serving several communities in the area. The project route ran beneath the Peralta Boulevard district of the town and involved the crossing of several arterial roads in central Fremont with pipes inverts at depths of between 12 and 20 ft below ground surface.

WORKS

It was decided to utilise microtunnelling to install some 2,860 ft of the 18 inch diameter pipe with open cut being used for the remainder. Initial indications showed that ground conditions would comprise medium stiff sandy clays and clayey sands, loose to medium dense silty and sandy soils and medium dense to dense gravels. Ground water levels were expected to be below the projected invert of the new pipelines. The contract documents specified the 12 in and 18 in diameter open cut works should be laid using PVC pipe whilst the 18 in diameter microtunnels were to be either vitrified clay or fibreglass reinforced plastic mortar pipe.



Removing the microtunneller at the end of the drive.

After competitive bidding the contract was awarded to Mountain Cascade, Inc (MCI) of Livermore, California, with Nada Pacific of Caruthers, California as its micro-tunnelling subcontractor, utilising an Akkerman SL24 slurry boring machine

equipped with a 26 in diameter cutting head with a crusher chamber, high pressure water jets and bentonite ports in the tails shield. MCIs bid included the microtunnelling being completed with the clay pipes.

At an early partnering session on the project potential difficulties were discussed in relation to the microtunnelling works including the long drive lengths, several of the 19 proposed drives being over 320 ft long, and the possible presence of cobbles and boulders within the pipe route which might cause difficulties for the microtunneller and clay pipes specified in the contract.

Drive length was a concern due to the inability to use intermediate jacking stations in the pipeline or booster pumps in the 3 in diameter slurry lines. Also, should the microtunneller encounter boulders greater than 8 in diameter, it was expected that boring would have to cease. This possibility also raised concerns for the clay pipe in that boulders by-passed by the cutter head might settle onto the new pipe causing point loadings high enough to fracture the pipeline or that, on the longer drives, jacking forces could reach levels which would cause the lead pipes in the pipejack to fail (in excess of the 190 t limit of the pipes).

The partnering process led to a suggestion from MCI/Nada that, in drives over



Delivery to site of the 24½ in diameter polycrystalline pipes from Meyer Germany.

360 ft long vitrified clay pipes be replaced by Polycrete pipes manufactured by Meyer Rohr & Schacht of Germany. Polycrete pipe comprises a plastic composite material made of sand, gravel, polyester resin and quartz powder which is formed and cured in moulds and post-cured in a kiln. The pipes contain no steel reinforcing and are designed to withstand high compressive loads whilst being corrosion resistant. Use on the Fremont project would be its first application in North America, despite previous wide use in Europe. The contractors also felt that its

durability would also overcome concerns about boulder point loads after installation. The Sanitary Authority accepted the proposal agreeing to adjust pricing levels to cover the additional costs of shipping the Meyer pipes.

DRIVES

Microtunnelling work started prior to the arrival of the Polycrete pipes using the available clay units. On the first drive boring ceased some 120 ft short of the 350 ft

target due to a plugging of a slurry line. During efforts to recover the microtunneller, it was discovered that the three leading clay pipes were severely cracked. In attempting to push these damaged sections into the recovery shaft for removal the cracked spread. It was decided to complete the drive in open cut.

The planned second microtunnel drive, beneath an over head rail crossing, did not start due to the presence of boulders in both start and reception shafts. This was also completed by open cut.

A second drive which did start ceased some 90 ft short of its target again due to a rock plugged slurry line. This was again completed in open cut.

Observations made in several test pits led the project team to stop using clay pipes altogether. Four proposed drives in what was expected to be very cobbly ground were completed using open cut and short auger bores at crossing points. On four other proposed drives, of lengths between 90 and 127 ft, 30 in diameter steel cased auger bores were utilised to cross under tree-lined roadways. PVC pipe was installed inside the casing with cellular concrete being used to grout the pipes into place.

Nada did complete one further microtunnel drive whilst awaiting the arrival of the Polycrete pipes from Germany. This ran under an expressway and was installed using welded steel casing.

Arrival of the Meyer pipe allowed commencement of the fourth drive, a 362 ft run which was completed in just two days.

In all some 5 drives were completed using the Polycrete pipes. Jacking loads during the drives ranged from 200 to 310 t. Despite these loadings post installation inspection of the new pipelines showed the joints, which comprised a glass-fibre reinforced plastic collar with a joint seal, appeared to be sound. Each pipe was also successfully pressure tested.

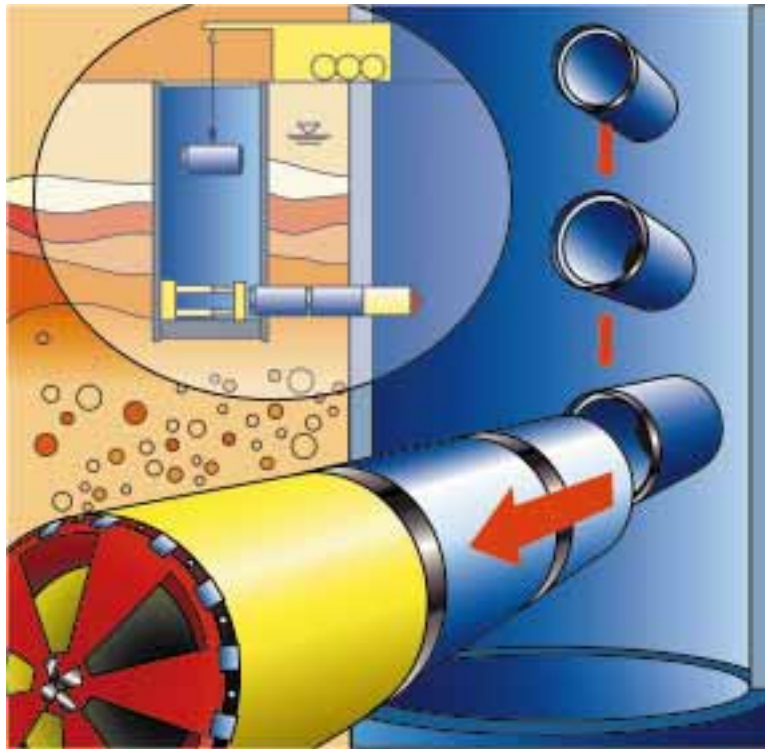
A final microtunnelled drive was carried out using Permalok steel pipe casing. This was a trial bore of 384 ft to show the compatibility of the pipe to the technique in such applications.

Despite the problems, the partnering methodology and the attitude of 'get it built' adopted by both owner and contractors led to the successful completion of the contract.

Technical assistance and field engineering services were provided to the project construction manager, O'Brien-Krietzberg (San Francisco), by Jacobs Associates of San Francisco. The project design was provided by Montgomery Watson of Walnut Creek, California.

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- **parallel pipe ends** = provides uniform distribution of jacking forces
- **high dimensional accuracy** = no ovality, tight joints and perfectly matching pipes
- **elasticity** = reduced point loading and risk of rupture
- **high corrosion resistance** = reliability throughout a long service life
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by Dan Adams

Jacobs Associates

CURVED DRIVES ROUND MORSBROICH CASTLE



Meyer Polycarbonate pipe being positioned during the Morsbroich Castle pipejacking project.

Unfavourable soil conditions and property access around the site of Morsbroich Castle in Leverkusen, Germany has, for some time, prevented the extension of the DN 800 combined water collector sewer which runs between Schlebusch and Leverkusen just north of Köln, Germany. The capacity of the existing 450 m long DN 400 sewage system has limited extension of the Schlebusch district and the drainage of other areas in the vicinity. The DN 800 sewer was designed as a replacement for the existing line to alleviate this problem. Various routes for the new sewer were considered in an attempt to meet all of the environmental, cultural and property protection requirements.

OPTIONS

The simplest route was a straight open-cut operation through the Morsbroich fruit

growing estate which was proposed as long ago as 1980. This was, however, not possible due to a veto exercised by the property owners and tenants.

A second attempt to find a route started in mid-1990 with a proposal to tunnel in a straight line under the castle. The Building Surveyors Office insisted that no subsidence could be allowed due to the historic listed buildings along the route. It was known that these buildings had poor rubble foundations which could easily be disturbed. Test boring of the area showed that this option could not be carried out to the exclusion of all subsidence and so the plan was rejected. In early 1991, a further option was put forward where three open-cut lengths of pipeline would be installed on a polygonal layout following the periphery of the castle moat. Ground conditions found during investigation of this route proved to be extremely permeable sand and gravel

which would have necessitated the draining of the moat. In addition to this a 60 m copse of trees aged at about 100 years would have had to be cut down. This route too was rejected, this time by the landscape committee.

SOLUTION

Despite the problems encountered in earlier plans the growth of trenchless technology eventually offered a solution to the Morsbroich Castle dilemma.

A plan was drawn up which included the driving of a straight 195 m long DN 800 pipejacked installation along the Auerweg, an approach road to the castle. This was to be followed by the curved pipejacking of a DN 1200, 212 m long installation alongside the castle moat with two DN 800 pipes being laid, of 20 m and 18 m length respectively, on both sides of

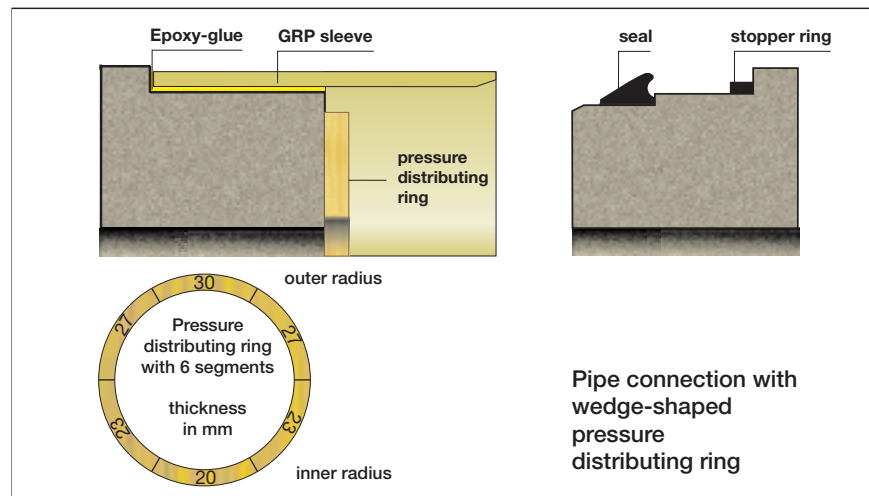
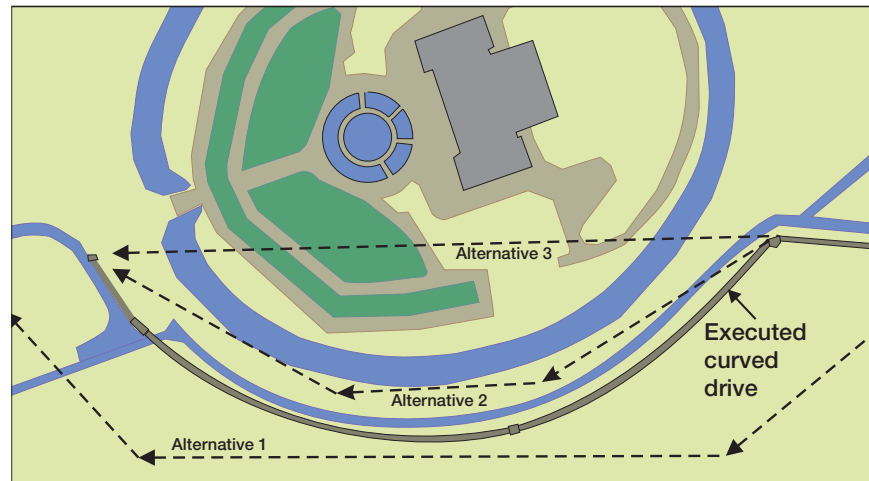
the main pipe to allow for connection with the existing sewer.

The straight line sections of the proposed project proved easy to plan with the degree of knowledge currently available to the industry. The curved section however proved more difficult with specialist companies being consulted on the practicalities of such a plan.

As for the pipe itself, this was required, by the Civil and Underground Engineering Office, to be made of a corrosion resistant

material with good flow characteristics and long-lasting watertight joints. As well as this the pipe was also required to withstand high eccentric loading, as would be applied during the curved pipejack, whilst maintaining a tight joint with the angular deflection caused by the curved route.

In the event, the client, Leverkusen City and Wayss & Freytag and Philip Holzmann, the contractor, chose polymer concrete pipe material as meeting all of the criteria laid down by the engineers.



Polycarbonate jacking pipe DN 1200, construction length 1 m



Polycarbonate jacking pipe in the reception shaft

DRIVES

The contract for the pipe was awarded to Meyer of Lüneburg, manufacturer of Polycarbonate pipe. Not only could Meyer supply the pipe in the required material but also in the short time frame required by the project. The first drives to be installed were two straight lengths of 147 m and 45 m respectively the first taking 10 days to complete and the second 4 days. The smooth outer diameters of the jacking pipes helped to achieve advance rates of up to 20 m/d (10 pipes). The curved section of the driving operations required called for particular parameters to be maintained including the curve radius of 115 m and a strict gradient of 1:138. The curve negated use of laser alignment for directional control and so main measurements were carried out once each week with the pipe position being monitored up to four times per day using electromagnetic detection.

In the event, the combined monitoring of the pipe alignment proved excellent with a maximum horizontal deviation off route of only 80 mm being recorded.

The sewer alignment runs just 2 m beneath the bed of the castle moat and only 4.5 m to one side of it, indicating the need for watertight jointing in the extremely wet conditions. The 212 m length was to be installed in one continuous run using two main jacking units, each with a capacity of 560 t, and two intermediate jacking stations, each with a capacity of 420 t.

The Meyer-manufactured pipes were designed to withstand axial forces of up to 600 t, having a wall thickness of 145 mm. To achieve the optimum radius of curvature and minimise eccentric jacking forces the pipes for the curved run were made in 1 m lengths. Jacking force distribution rings were fitted in each pipe joint and were made of knotless, wedge-shaped soft wood to distribute, as well as centralise, the forces on the pipe, thus stabilising the jacking of the curved section.

The work was completed within a 52 week period without any harm befalling the local environment or the listed buildings on the site. The estimated cost of the whole project has been put at DM 2.4 million, with the Polycarbonate pipes fully maintaining their expected performance throughout the scheme.

by Dipl.Ing. Jürgen Funke
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POLYMER CONCRETE PIPES

Highly filled thermosetting resin concrete has been used for decades in the chemical industry, engineering construction (machine foundations), the building industry (facade products and sanitary items), and in electrical engineering.

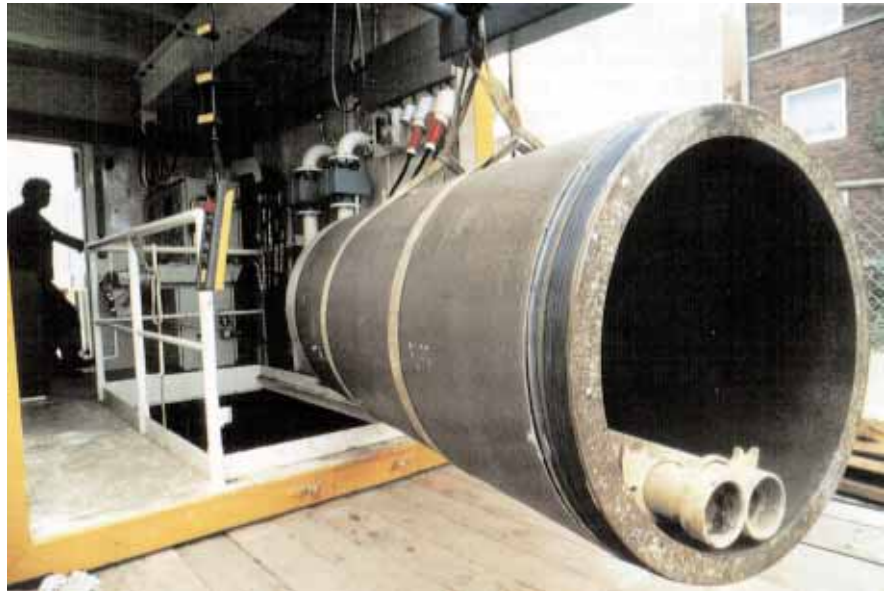
This is due mainly to a number of favourable properties including strength, elasticity and corrosion resistance. The material, also commonly described as polymer concrete or mineral casting, comprises the bonding agent, the thermosetting resin, and a large proportion of mainly mineral fillers.

The development of pipes in polymer concrete dates from the early 1960s. The aim was to achieve a substantial increase in both resistance to chemical attack from the inside and outside, and strength in terms of stresses from external and internal loads whilst retaining the economical advantages of the pipe as a pre-fabricated finished part (1).

Up to 1969 around 50,000 t of polymer concrete pipe had been manufactured in Germany in nominal diameters from DN 300 to DN 3,500 using either polyester or epoxy resins as the bonding agent in either prestressed reinforced or plain designs. These were mainly used and tested as waste water collectors in the chemical industry substantiating reliability of the technology. Despite early successes and the properties of the product, polymer concrete pipes were not, at first, permanently accepted in the market.

Manufacturing was abandoned after some time mainly for either cost reasons and due to the fact that some aspects of the manufacturing technology had not been adequately mastered.

However, over the past ten years the processes for manufacture of pipes and manholes in polymer concrete have fundamentally improved, making available



Meyer Polycrrete jacking pipes of DN 800 being used on a project near Hamburg airport.

economic alternative to other corrosion resistant pipe materials.

POLYMER CONCRETE

Polymer concrete pipes consist of up to 90% quartzitic, oven dried fillers, including mineral sands and grit with a grading curve of 0 to 16 mm, with polyester resin as a bonding agent. They do not contain any cement, instead the polyester resin brings about the bonding between the fillers after curing and gives the pipes the additional positive properties of elasticity and resistance to fracture and chemical attack.

Plastics are macro-molecular compounds, that is large scale molecules which have originated from the amalgamation of smaller basic molecules. 'Polymer' (Greek)

means 'consisting of larger molecules'. Thus plastics are also described as high polymer materials and aggregates with plastic as a bonding agent are described as 'polymer concrete'.

Polyester, vinylester or epoxy resins are used as thermosetting bonding agents, according to the requirements set for the chemical resistance of the material.

These plastics are so-called thermosetting plastics, which are fully cured after a chemical reaction (polymerisation or polyaddition) and cannot be melted again. This is quite the opposite to the thermoplastics, such as PVC and PE, which warp and finally melt under the effects of heat due to the different molecular structure. With thermosetting plastics spatial grid molecules arise during curing, that is the creation of three-dimensional chemical compounds whereas with thermoplastics single chain molecules form with disordered structure so they can slide against each other. In addition thermosetting plastics do not become brittle at temperatures below 0° C.

MANUFACTURE

Polymer concrete pipes have been manufactured by various processes including centrifugal, centrifugal rolling and the vibrating process, both with and without reinforcement. In the vibrating process which is currently used the materials are mixed in a computer-controlled metering

Compressive strength	100 to 120 N/mm ²
Modulus of elasticity	28,000 N/mm ²
Tensile strength	6 N/mm ²
Ring bending tensile strength	16 N/mm ²
Ring fatigue strength	6 N/mm ²
Abrasion resistance	0.2 mm/100,000 load cycles
Absolute wall roughness	0.1 mm

Typical mechanical properties obtained in finished polymer concrete jacking pipes

and preparation installation and then loaded into a vertical metallic mould, consisting of an inner core and an external shell. After compaction on the vibrating table the pipe cures in the mould. Once removed from the shell it is post-cured in a tunnel kiln. This method allows circular and oval pipes as well as special cross-sections such as man-hole shaft pipes, cones and other auxiliary components to be manufactured.

The pipe joint is manufactured from glass fibre reinforced polyester resin as a separate connector coupling using a winding process. The elastomer, sealing and spacer rings are laminated in with it, meeting the requirements of DIN 4060 standards for sealing rings in elastomers for pipe joints'.

PROPERTIES

Mechanical properties of the polymer concrete in finished pipes can be seen in the accompanying table.

Using polyester resin as the binder gives resistance against 'very strongly corrosive and aggressive' media in accordance with DIN 4030 standards and depending on the type of resin utilised pipes can be used in environments with pH values of between 1 and 13. For highly polluted waste water polymer concrete pipes can also be manufactured using epoxy resin.

The advantages of polymer concrete pipes is the combination their high corrosion resistance against aggressive waste waters and soils along with the high static load carrying capacity which exists despite the relatively low weight, low internal wall roughness, and high abrasion resistance.

RANGE

Various forms of polymer concrete pipe are manufactured including standard sewer pipes in diameters of between DN 300 and DN 2,500 in 3 m construction lengths. Joints are made using glass fibre reinforced, polyester resin couplings with an integrated elastomer double lip seal with centre stop web. Pipes and couplings are watertight and tested to 2.4 bar pressure. Side connection pipes of 45° and 90° can also be supplied.

Non-Circular sections are also supplied with dimensions in accordance with DIN 4263 standard. In width/height sizes of 300/400 to 700/1,050 construction lengths are 2.5 m with wall thicknesses of between 40 mm and 80 mm. In width/height sizes of 800/1,200 to 1,400/2,100 construction length is 2 m with wall thicknesses of 90 mm to 150 mm. Jacking pipes are manufactured to wall thicknesses which, from experience, have been shown to be adequate to withstand the axial stresses of jacking. The full range of

internal diameter mm	external diameter mm	wall thickness mm	length m	permitted compressive force tons	permitted compressive force kN	pipe weight kg/m
150	208	29	1	16	160	37,5
200	275	37,5	1	21	210	62
250	360	55	1 and 2	53	530	117
300	400	50	1 and 2	51	510	122
400	550	75	1 and 2	150	1500	249
500	660	80	2	190	1900	324
600	760	80	2	224	2240	380
700	860	80	2	240	2400	435
800	960	80	2	272	2720	490
900	1000	100	2	448	4480	700
1000	1184	92	2 and 3	414	4140	697/703
1200	1482	141	3	570	5700	1327
1400	1720	160	3	740	7400	1750
1600	1940	170	3	890	8900	2100

Range and dimensions of the most commonly used polymer concrete jacking pipes

jacking pipes is given in the accompanying table.

In special cases jacking pipes can be manufactured with thicker walls to withstand higher compressive forces.

The jacking pipe joint comprises a mounted collar integrated into the pipe wall which is made of glass fibre plastic or stainless steel with a joint seal of microcellular expanded rubber and sealing sections. Load transfer rings of press board or knotless soft wood in thicknesses of between 10 mm and 25 mm are incorporated into the joint depending on the pipe diameter to ensure uniform load transfer between adjacent pipes.

Manhole section manufacture is carried out so as to provide a one piece easy-to-fit construction which will conform to the requirements of a site as required and yet be available in just a few days of order. Using similar materials to those used for pipe manufacture, manholes are made in accordance with DIN 4034 to DN 1,000 for connections up to DN 500, DN 1,200 for connections up to DN 800 and DN 1,500 for connections up to DN 1,000.

Fitting lengths are sometimes required for pipe installations where changes in route or obstacles are encountered. With polymer concrete these lengths can be made up on site as necessary.

Side connections are also a requirement of most pipelines and these are manufactured in diameters of DN 150 or DN 200 either in the factory or on site including 45° connections for up to DN 400 main pipes, above this diameter it is advised that 90° connections are used.

Although generally used in gravity situations polymer concrete pipes can be operated in pressure situations in circumstances where pressures do not exceed PN 1.6, in accordance with the minimum requirements for sewers in zone II water protection areas, where they are open laid. Polymer concrete

sewer pipes were given a PA-I3939 approval by the Institut für Bautechnik in Berlin and the pipes are regularly tested for quality by the Government Material Testing Authority of North Rhine-Westphalia.

FUTURE

The well proven mechanical and chemical performance of polymer concrete has been supplemented with improved manufacturing technology which now makes the material ideal for pipes for use in microtunnelling, pipejacking and sewer applications in general. Increasing use of this material is being seen and world-wide licensing of this new technology will continue this trend.

Examples of the increasing interest in polymer concrete pipes is shown with the announcement that during the course of the Leitungsbau conference and exhibition in Hamburg, Germany between October 16 and 20, Meyer Pipes Engineering will be participating in four demonstration projects. One is pipe burst replacement project for contractor Hans Franck using DN 600 jacking pipe over 320 m. The second is a 296 m microtunnelling project with DN 800 pipe for contractors Lafrentz and Peter Geisler. The third is a pipe jacking project over 286 m using kite-shaped pipe of 1,200 mm/1,490 mm dimensions for contractor Meyer and John. Finally, the fourth installation is that of 276 m of eggshaped segments of dimensions 700 mm/1,200 mm also for contractor Meyer and John.

by Thomas D. Bloomfield

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TO THE POINT.

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- high compressive strength = high jacking force and maximum safety
- steel guide collar = maximum safety during jacking
- smooth, even, non-absorbing outer pipe surface = reduces friction
- parallel pipe ends = provides uniform distribution of jacking forces
- high dimensional accuracy = no ovality, tight joints, and perfectly matching pipes
- elasticity = reduced point loading and risk of rupture
- low weight = ease of installation
- adaptable dimensions = suitable for all microtunnelling and jacking equipment
- complete system = reinforced concrete insertion and reception shafts, POLYCRETE® jacking pipes, and POLYCRETE® system manholes all from the same supplier
- smooth, even inner surface = high flow rate
- high corrosion resistance = reliability throughout a long service life
- tested fatigue strength under cyclic load = installations under German, Canadian and U.S. railroad tracks have been approved



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