Sika® ViscoCrete® Technology for Precast Concrete

The Malmö City Tunnel in Sweden

**Project**
The Malmö City Tunnel is part of a 17 km long railway project, which connects Malmö Central Station with the Öresund Bridge. The investment for the whole project is about 1 billion € and the construction period will be from 2005 to 2007. The Malmö City Tunnel will have a length of 6 km with two tubes, 4.5 km of it drilled by a Tunnel Boring Machine (TBM). The construction of this section will take just 52 months and cost approximately 250 Mio. €.

**Requirements**
The tunnels will be built as a «tunnel in the tunnel» with precast segments. All of the segment joints will be sealed so the tunnel will be waterproof from the start. For safety and security reasons the two main tunnels will also be connected with 13 side tunnels every 300 – 500 metres.

**Sika Solution**
The Sika solution is a watertight concrete with a slump of 40 - 60 mm and an ultimate compressive strength higher than 70 MPa. Additionally the concrete has an improved fire resistance, achieved by the addition of PP fibres, and achieves high early strengths. The Sika products used on this project to date are Sika® ViscoCrete®-2320 (360 tonnes) for the precast segments, Sigunit®-L53 AF (300 tonnes) for the initial shotcrete lining and Sikament®-EVO 26M (180 tonnes) for the general ready mixed concrete.

The Hallandsås Railway Tunnel Project in Sweden

**Project**
The Hallandsås railway tunnel project is part of the west coast railway connecting Gothenburg with Malmö, through the Hallandsås rock ridge in south west Sweden. The completed west coast railway will half the travelling time from Gothenburg to Malmö. The tunnel consists of two parallel tunnels each with a length of 8.6 km, drilled with a Tunnel Boring Machine (TBM). The cost of the completed tunnel is estimated at 793 Mio. € and it is scheduled for the first trains to pass through the tunnels in 2012.

**Requirements**
Difficult tunnelling conditions with hard, fissured and water bearing zones make the construction of a watertight concrete tunnel necessary. With the TBM a total of 41’000 precast tunnel segments will be placed during the 3 year construction period, requiring a total concrete volume in excess of 180’000 m³. Technically the major challenge was to achieve the required high early strength of 17 MPa after only 9 hours with autoclave curing of the concrete segments at 40°C.

**Sika Solution**
The Sika solution was development of a superplastizzaer based on Sika® ViscoCrete® technology, which fulfills all of the design requirements. The fresh concrete is soft and easy to cast with a slump of 35 mm retained for 45 minutes at 20°C. The compressive strength of the concrete exceeds 70 MPa after 28 days. Sika was the only admixture producer out of 6 evaluated, that was able to meet the demanding specifications for this project.
Sika® ViscoCrete® Technology for Precast Concrete

The San Francisco Hydroelectric Power Project in Ecuador

Project
The San Francisco hydroelectric power project is one of the most important construction projects in Ecuador and it is situated near the city of Baños. The hydroelectric power station will have a capacity of approximately 210 MW. Part of the project is an 11 kilometre long water conduction tunnel, 30% of which is being constructed with a Tunnel Boring Machine (TBM). The tunnel lining consists of 7'400 precast concrete tunnel segments, which have a total concrete volume of 6'900 m³.

Requirements
For the production of this number of tunnel segments a production plant was built close to the construction site to ensure the continuous supply of segments to the Tunnel Boring Machine. For the concrete properties an early segment 'lifting' strength of 10 MPa after 6 hours was required, with a compressive strength of 45 MPa specified at 28 days.

Sika Solution
Several possible concrete mix designs were tested in order to achieve the high early strength after just 6 hours. The contractor decided to steam cure the tunnel segments for 3.5 hours to enable an even faster production process. The trials proved that the mix design with Sika® ViscoCrete®-20 HE was able to fulfill all of the requirements and to date approximately 30 tonnes of Sika® ViscoCrete®-20 HE have been used to produce these segments very successfully.

The Thurrock Viaduct - part of the Channel Tunnel Rail Link (CTRL) in the UK

Project
The Thurrock Viaduct is part of a 260 Mio. € contract, which covers the above ground route of the CTRL between the London Tunnel at Dagenham and the Thames Tunnel at Thurrock. Overall this included the design and construction of three viaducts and associated railway construction works. The overall concrete volume used in this section of the project was over 200'000 m³.

Requirements
The largest and most prominent structure on the CTRL is the Thurrock Viaduct. The deck of the 23 span prestressed box girder viaduct at Thurrock was constructed using the incremental launch system and with a length of 1,825 km, it will be the largest push-launch structure built in the UK. The hollow deck segments are precast directly on the site prior to each launch. Each segment is 3.5 m high, 12 m wide at the top, 11 or 12 m long and each one weighs approximately 300 tonnes.

Sika Solution
Sika admixtures Sikament® N and CW, based on Sika® ViscoCrete® technology, were selected to provide the constant year round workability, concrete flow and high early strengths. Almost 1 million litres of the Sika superplasticisers and the high performance retarder, Sika® Retarder®-50, were used in the site batched concrete for the bridge segments and other structural elements, by the time the project was completed in 2004. Additional constant monitoring of temperature changes and concrete workability were made to ensure that the precise levels of water retention, concrete flow and high early strengths were achieved and maintained.

The National Opera House in Oslo , Norway

Project
The National Opera House is a 310 Mio. € project situated at Bjørvika in Oslo. The construction period is over 5 years with completion scheduled in 2008. It will cover an area of 36'000 m² with 1'350 seats in the main auditorium and 400 seats in the smaller hall. The unique appearance of the Opera House arises from the icicle shaped precast concrete columns which support the roof structure.

Requirements
The precast columns have a length of between 4 m and 21 m, and weigh between 4 tonnes and 24 tonnes respectively. The precast volume will total 12'000 m³ of concrete, with an additional volume of 120 m³ for the special white precast feature columns. The architects design requirements for the icicle shaped precast columns were to achieve a reflective, snow white concrete surface with a very high quality finish. In order to achieve such a white appearance, white cement was combined with bright white marble aggregates from western Norway.

Sika Solution
A Self Compacting Concrete based on Sika® ViscoCrete® technology was developed for the white precast columns. The Sika® ViscoCrete® ensured sufficient fresh concrete stability coupled with a powerful water reducing effect. The required dosage was 1.5% by weight of cement. The admixture reduced bleeding, and subsequently reduced the formation of pores in the surfaces. To achieve the ideal Self Compacting Concrete a white dolomite filler was added to compensate for a low content of fine materials in the crushed marble aggregates. The hardened precast columns were also treated after demoulding and curing with Sika® Antigrafi tti-15 as a clear, non yellowing, protective impregnation to prevent future surface contamination.

Major Precast Production in the USA

Project / Requirements
A major precast company, producing all kinds of structural units at plants across three states, was looking to develop a single standard mix design for Self Compacting Concrete. This would have to meet all their standard production requirements which in detail meant:

- Fast strength development of 26 MPa after 12 hours and 48 MPa after 28 days
- No vibration
- Good and easy to brush / broom finish
- Extended workability

Sika Solution
The Sika solution was mainly based on Sika® ViscoCrete® technology combined with SikaRapid® and SikaFume®. This was established and confirmed by an intensive testing programme of 25 different possible mix designs, resulting in the successful mix meeting the requirements and also giving the following improvements:

- Slump flow improved from 580 mm to 620 mm
- 'Bug hole' rating was decreased from 1.8 to 0.6 (surface voids)
- A very good brush / broom finish was achieved
- Mix design conformed to PCI guidelines for SCC (USA Precast Concrete Institute)

All of these technical improvements were obtained at the same time as a substantial increase in the cost performance of the companies overall precast production.
Sika® ViscoCrete® Technology for Precast Concrete

The San Francisco Hydroelectric Power Project in Ecuador

Project
The San Francisco hydroelectric power project is one of the most important construction projects in Ecuador and it is situated near the city of Baños. The hydroelectric power station will have a capacity of approximately 210 MW. Part of the project is an 11 kilometre long water conduction tunnel, 80% of which is being constructed with a Tunnel Boring Machine (TBM). The tunnel lining consists of 7'400 precast concrete tunnel segments, which have a total concrete volume of 6'900 m³.

Requirements
For the production of this number of tunnel segments a production plant was built close to the construction site to enable the continuous supply of segments to the Tunnel Boring Machine. For the concrete properties an early segment «lifting» strength of 10 MPa after 6 hours was required, with a compressive strength of 45 MPa specified at 28 days.

Sika Solution
Several possible concrete mix designs were tested in order to achieve the high early strength after just 6 hours. The contractor decided to steam cure the tunnel segments for 3.5 hours to enable an even faster production process. The trials proved that the mix design with Sika® ViscoCrete®-20 HE was able to fulfill all of the requirements and to date approximately 30 tonnes of Sika® ViscoCrete®-20 HE have been used to produce these segments very successfully.

The National Opera House in Oslo, Norway

Project
The National Opera House is a 310 Mio. € project situated at Bjørvika in Oslo. The construction period is over 5 years with completion scheduled in 2008. It will cover an area of 36'000 m² with 1'350 seats in the main auditorium and 400 seats in the smaller hall. The unique appearance of the Opera House arises from the icicle shaped precast concrete columns which support the roof structure.

Requirements
These columns have a length of between 4 m and 21 m, and weigh between 4 tonnes and 24 tonnes respectively. The precast volume will total 12'000 m³ of concrete, with an additional volume of 120 m³ for the special white precast feature columns. The architects design requirements for the icicle shaped precast columns were to achieve a reflective, snow white concrete surface with a very high quality finish. In order to achieve such a snow white appearance, white cement was combined with bright white marble aggregates from western Norway.

Sika Solution
A Self Compacting Concrete based on Sika® ViscoCrete® technology was developed for the white precast columns. The Sika® ViscoCrete® ensured sufficient fresh concrete stability coupled with a powerful water reducing effect. The required dosage was 1.5% by weight of cement. The admixture reduced bleeding, and subsequently reduced the formation of pores in the surfaces. To achieve the ideal Self Compacting Concrete a white dolomite filler was added to compensate for a low content of fine materials in the crushed marble aggregates. The hardened precast columns were also treated after demoulding and curing with Sika® Antigraffiti-15 as a clear, non yellowing, protective impregnation to prevent future surface contamination.

The Thurrock Viaduct - part of the Channel Tunnel Rail Link (CTRL) in the UK

Project
The Thurrock Viaduct is part of a 260 Mio. € contract, which covers the above ground route of the CTRL between the London Tunnel at Dagenham and the Thames Tunnel at Thurrock. Overall this included the design and construction of three viaducts and associated railway construction works. The overall concrete volume used in this section of the project was over 200'000 m³.

Requirements
The largest and most prominent structure on the CTRL is the Thurrock Viaduct. The deck of the 23 span prestressed box girder viaduct at Thurrock was constructed using the incremental launch system and with a length of 1'625 km, it will be the largest push-launch structure built in the UK. The hollow deck segments are precast directly on the site prior to each launch. Each segment is 9.5 m high, 12 m wide at the top, 11 or 12 m long and each one weighs approximately 300 tonnes.

Sika Solution
Sika admixtures Sikament® N and CW, based on Sika® ViscoCrete® technology, were selected to provide the constant year round workability, concrete flow and high early strengths. Almost 1 million litres of the Sika superplasticiers, and the high performance retarder, Sika® Retarder®-50, were used in the site batched concrete for the bridge segments and other structural elements, by the time the project was completed in 2004. Additional constant monitoring of temperature changes and concrete workability were made to ensure that the precise levels of water retention, concrete flow and high early strengths were achieved and maintained.

Major Precast Production in the USA

Project
A major precast company, producing all kinds of structural units at plants across three states, was looking to develop a single standard mix design for Self Compacting Concrete. This would have to meet all their standard production requirements which in detail meant:

- Fast strength development of 26 MPa after 12 hours and 48 MPa after 28 days
- No vibration
- Good and easy to brush / broom finish
- Extended workability

Sika Solution
The Sika solution was mainly based on Sika® ViscoCrete® technology combined with SikaRapid® and SikaFume®. This was established and confirmed by an intensive testing programme of 25 different possible mix designs, resulting in the successful mix meeting the requirements and also giving the following improvements:

- Slump flow improved from 580 mm to 620 mm
- ‘Bug hole’ rating was decreased from 1.8 to 0.6 (surface voids)
- A very good brush / broom finish was achieved
- Mix design conformed to PCI guidelines for SCC (USA Precast Concrete Institute)

All of these technical improvements were obtained at the same time as a substantial increase in the cost performance of the companies overall precast production.
The Malmö City Tunnel in Sweden

Project
The Malmö City Tunnel is part of a 17 km long railway project, which connects Malmö Central Station with the Öresund Bridge. The investment for the whole project is about 1 billion € and the construction period will be from 2005 to 2007. The Malmö City Tunnel will have a length of 6 km with two tubes, 4.5 km of it drilled by a Tunnel Boring Machine (TBM). The construction of this section will take just 52 months and cost approximately 250 Mio. €.

Requirements
The tunnels will be built as a «tunnel in the tunnel» with precast segments. All of the segment joints will be sealed so the tunnel will be waterproof from the start. For safety and security reasons the two main tunnels will also be connected with 13 side tunnels every 300 – 500 metres.

Sika Solution
The Sika solution is a watertight concrete with a slump of 40 - 60 mm and an ultimate compressive strength higher than 70 MPa. Additionally the concrete has an improved fire resistance, achieved by the addition of PP fibres and achieves high early strengths. The Sika products used on this project to date are Sika® ViscoCrete®-2320 (360 tonnes) for the precast segments, Sigunit®-L53 AF (300 tonnes) for the initial shotcrete lining and Sikament®-EVO 26M (180 tonnes) for the general ready mixed concrete.

The Hallandsås Railway Tunnel Project in Sweden

Project
The Hallandsås railway tunnel project is part of the west coast railway connecting Gothenburg with Malmö, through the Hallandsås rock ridge in south west Sweden. The completed west coast railway will half the travelling time from Gothenburg to Malmö. The tunnel consists of two parallel tunnels each with a length of 8.6 km, drilled with a Tunnel Boring Machine (TBM). The cost of the completed tunnel is estimated at 793 Mio. € and it is scheduled for the first trains to pass through the tunnels in 2012.

Requirements
Difficult tunnelling conditions with hard, fissured and water bearing zones make the construction of a watertight concrete tunnel necessary. With the TBM a total of 41’000 precast tunnel segments will be placed during the 3 year construction period, requiring a total concrete volume in excess of 180’000 m³. Technically the major challenge was to achieve the required high early strength of 17 MPa after only 9 hours with autoclave curing of the concrete segments at 40°C.

Sika Solution
The Sika solution was development of a superplasticiser based on Sika® ViscoCrete®technology, which fulfills all of the design requirements. The fresh concrete is soft and easy to cast with a slump of 35 mm retained for 45 minutes at 20°C. The compressive strength of the concrete exceeds 70 MPa after 28 days. Sika was the only admixture producer out of 6 evaluated, that was able to meet the demanding specifications for this project.