SIKA AT WORK
TUNNEL SEGMENT PRODUCTION WITH SikaRapid®

LIFE CYCLE IMPACT ASSESSMENT

BUILDING TRUST

TUNNEL SEGMENT PRODUCTION WITH Sikarapid®

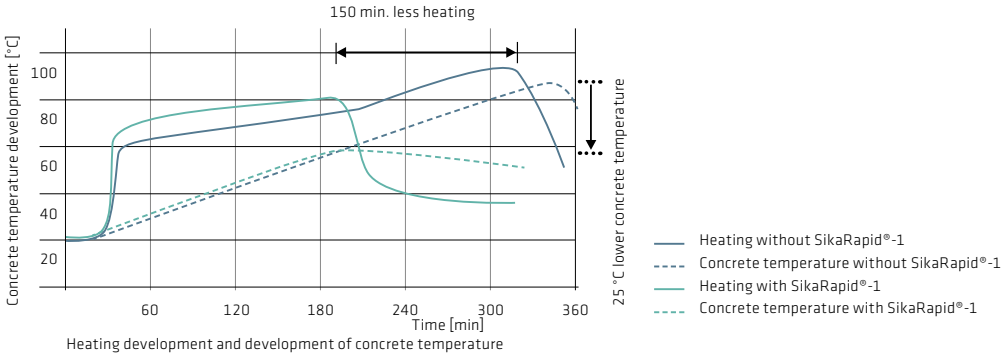
PROJECTS
Modern tunneling methods in weak rock conditions demand concrete segments which are immediately load bearing as linings to the fully excavated tunnel section. Precast concrete units called tunnel segments or Tübbings perform this function.

REQUIREMENTS
Due to the large numbers required and heavyweight (up to several metric tons each), tunnel segments are almost always produced close to the tunnel portal in specially installed precasting facilities. They have to meet high accuracy specifications. Heavy steel formwork is therefore the norm. Because striking takes place after only 5 – 6 hours and the concrete must already have a compressive strength of >15 N/mm², accelerated strength development is essential. There are several methods for this. In the autoclave (heat backflow) process, the concrete is heated to 28 – 30 °C during mixing (with hot water or steam), placed in the form and finished. It is then heated for about 5 hours in an autoclave at 50 – 60 °C to obtain the necessary strength for formwork removal.

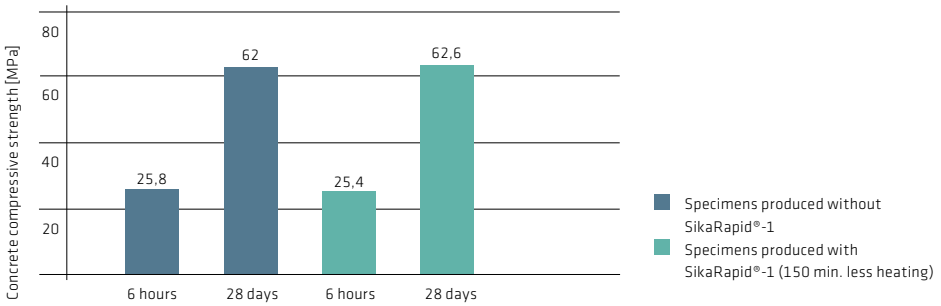
SPECIAL REQUIREMENTS
The newly demolded segments must be cured by covering or spraying with a curing agent such as Sika® Antisol®. However, to obtain a combination of maximum durability in variable ground conditions and optimum curing, the segment surfaces are treated more often with a special SikaGard® protective coating immediately after striking. With this additional protection against chemical attack, extremely durable concrete surfaces are achieved.

SIKA SOLUTIONS
Improved concrete hardening in tunnel segment production. Tunnel segment production combines the challenge of realization of a specified high early strength and fulfilment of highest requirements regarding durability. Strength development is usually secured by utilization of heat or steam curing which can be contradictory to durability if the concrete core temperature is too high. The concrete performance regarding early strength and durability can be enhanced with the SikaRapid® technology.

Exemplary heating cycles with and without application of SikaRapid® and the resulting concrete temperature with the corresponding early strength can be seen in the graphics below. With the application of SikaRapid® the hardening process of the concrete was optimized, with the result that approximately 150 minutes of heating could be eliminated. At the same time the early and final strength requirements were attained. Moreover the durability of the tunnel segments was improved as the concrete peak temperature was limited to less than 60°C.



Heating development and development of concrete temperature



Comparison of compressive strength

LIFE CYCLE IMPACT ASSESSMENT
Life Cycle Impact Assessment of two concrete systems to compare the impact in steam reduction with SikaRapid®-1

Concrete Systems	Components			
	Cement	**Additive**	**Sand / Gravel**	**Concrete Admixture**
Steam curing time: 150 min.				
High early strength concrete with SikaRapid®	CEM I 52,5 350 kg/m³	–	900 kg/m³ 1,030 kg/m³	Sika® ViscoCrete® 20 HE SikaRapid®-1
Steam curing time: 300 min.				
High early strength concrete	CEM I 52,5 350 kg/m³	–	900 kg/m³ 1,030 kg/m³	Sika® ViscoCrete 20® HE

DEFINITION LIFE CYCLE IMPACT ASSESSMENT
- Cradle-to-Gate, including packaging of the Concrete Admixtures (IBC container) and production of steam
- Functional Unit: 1 m³ concrete
- Modeled in the software GaBi, from PE-International accorfing to the ISO 14040 series

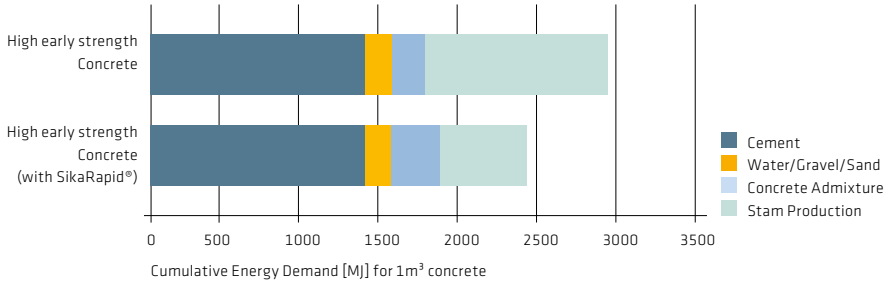
SAVING POTENTIAL TUNNEL SEGMENT PROJECT
Length: 5 km / Diameter: 14 m /
Thickness elements: 30 cm
Energy savings equivalent to 687'000 liter oil
Carbon savings equivalent to 1.50 Mio km (truck 15 to), 450,000 km (truck 15 ton)

LIFE CYCLE IMPACT ASSESSMENT

Environmental impacts and resource inputs

Cumulative Energy Demand [MJ]

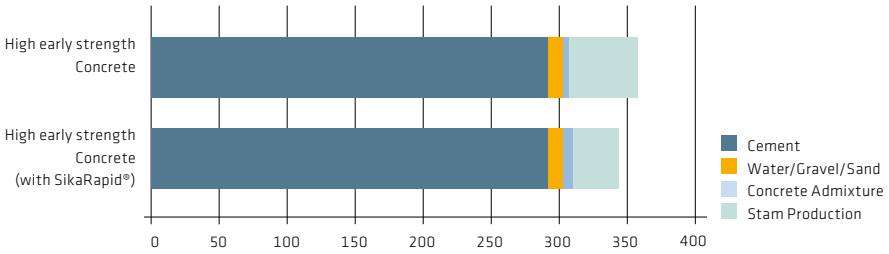
Total amount of primary energy from renewable and non-renewable resources



Cumulative Energy Demand [MJ] for 1m³ concrete

Global Warming Potential [kg CO_2-eq.], CML 2001

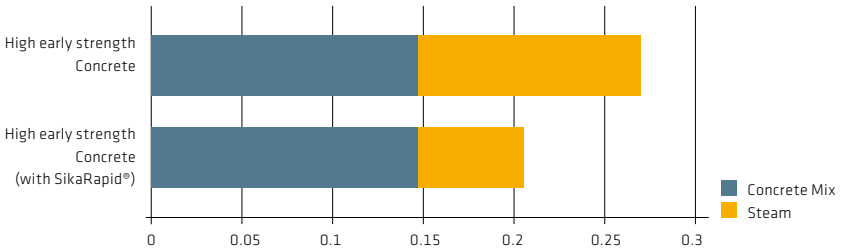
Potential contribution to climate change due to green-house gases emission



Global Warming Potential (GWP 100 years) [kg CO2-eq.] for 1m³ concrete

Input Water [m³]

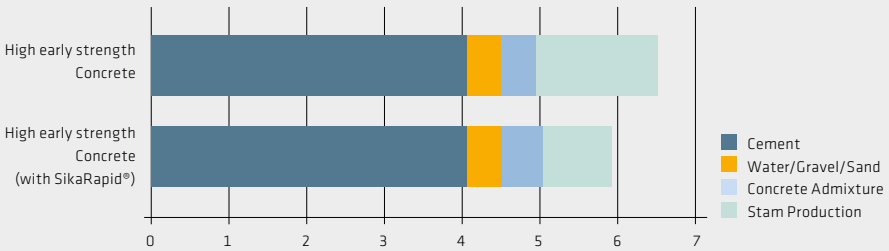
Consumption of water (for the concrete production)



Input Water [m³] for 1m³ concrete

ECO INDICATOR 99 [POINTS]

Impact score which takes into account several damage categories (to mineral and fossil resources, to ecosystem quality and to human health), which are then normalized and added to give a dimensionless result



Eco Indicator 99 [points] for 1m³ concrete

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