DUCON

DUCON Security

Explosion protection

Debris protection

Bullet resistance

Breakthrough inhibition

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DUCON-Security

DUCON® AS SAFETY CONCRETE FOR THE PROTECTION OF CRITICAL INFRASTRUCTURES

DUCON Security enables an effective increase in the protection of buildings against violent events (terror, war, etc.) with low component thicknesses. DUCON can be adapted to the overall architectural appearance due to its many design options. The security concrete has been used to protect numerous critical infrastructures, embassies, high-rise buildings, community centers, high-security data centers and nuclear power plants.

- Debris protection ceilings and façades
- Explosion protection + debris protection (anti-terror)
- Bullet and penetration resistance
- Earthquake protection
- Protective walls
- Column sheathing
- Mobile protection container against explosion and shelling

For protection against explosions, a considerable increase in the protective effect can be achieved with layers as thin as 4 cm, integrated into the outer wall. The bullet resistance of structures can be sustainably increased with DUCON.

KEYWORDS:

• „all-in-one“ • Debris protection • Explosion protection • Impact protection • burglar-resistant • bullet resistant

Image: DUCON-Security as safety concrete

e.g. Protective façade Consulate General

Content

Introduction

DUCON®

The combination of ultra-high strength concrete and spatial micro-reinforcement to produce a **high-performance concrete** with outstanding properties.

Company

Internationally active company founded in 2004 by the inventor of DUCON technology, Dr.-Ing. Stephan Hauser, with headquarters in Darmstadt.

Fields of application

The **Security, Overlay and Architectural & Design** business units describe the range of applications: from security concrete for endangered facilities and high-performance industrial flooring for the automotive and chemical industries to filigree special components for architects and designers.

Decisive advantages

Compared to the state of the art in concrete technology, DUCON is **thinner, lighter and more ductile** while maintaining the **highest load-bearing capacity**.

Reference projects

The reference projects mentioned range from critical infrastructure, high security data centers, chemical industry to endangered facilities. The project descriptions provide a very good insight into the diverse application areas of DUCON technology.

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1. The DUCON-Technology

DUCON – (DUctile CONcrete)

DUCON® is an innovative, patented high-performance material which, in addition to its high strength, is characterized by high energy absorption (ductility) and durability, and at the same time enables the realization of low component thicknesses (from 15 mm). DUCON is mainly used for the protection of endangered facilities and critical infrastructures due to its high protective effect against explosion, impact, shelling and earthquakes.The range of applications for this modern high-performance material extends from safety concrete (anti-terror), industrial surfaces, filigree staircases, facades and special architectural components to thin tabletops. As a rule of thumb for explosion protection, DUCON is at least four times as powerful as conventional reinforced concrete and can thus be designed with half the component thickness and thus half the component weight compared to reinforced concrete.

DUCON currently embodies the thinnest construction with simultaneous high load-bearing capacity and protective effect in the concrete area.

Highlights DUCON:

- Thinnest solution for explosion protection (One World Trade Center New York, German Embassy Kabul: unharmed after terrorist attack on 31.05. 2017
- Thinnest cantilever concrete staircase in the world (folding staircase, 80mm thin)
- Thinnest roof shell in the world ("Parapluie", 25-30mm, Tsuboi Award 2013)
- Thin energy efficient building envelope, 11m long, 55mm thin, thermally activated (ETA factory)
- Thin concrete house, 30 mm wall and roof thickness ("Haus im Weinberg", TU Kaiserslautern, Innovation Award Rhineland-Palatinate 2012)
- Jointless industrial floors and sealing layers

Fields of application:

- Structural protection of vulnerable facilities and critical infrastructure
- Façades, architectural concrete
- Repair of buildings and traffic areas
- Waterproofing of structures (WHG surfaces)

Image: "Parapluie" d= 25 – 30mm
= thinnest roof shell

Image: cantilever folding staircase d=80mm
= thinnest concrete stairs

2. DUCON®-Security

2.1 Hardening measures

DUCON curing measures in the inventory
One material structure for multiple performance ("all in one" solution)

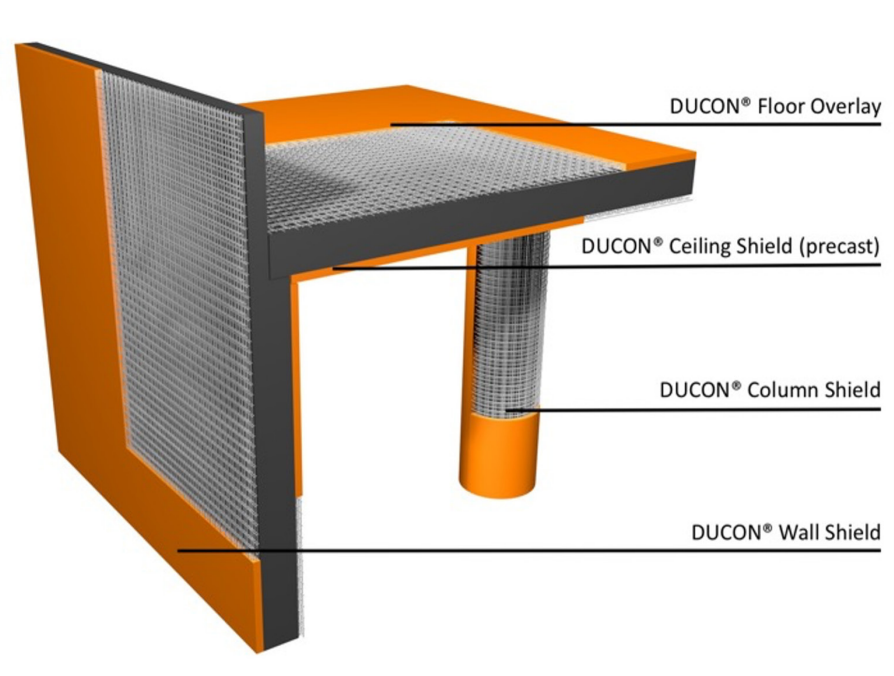


Image: DUCON-Security

Properties:
- High load capacity
- High bullet resistance
- High explosion protection
- High debris protection
- High durability
- High ductility and energy absorption

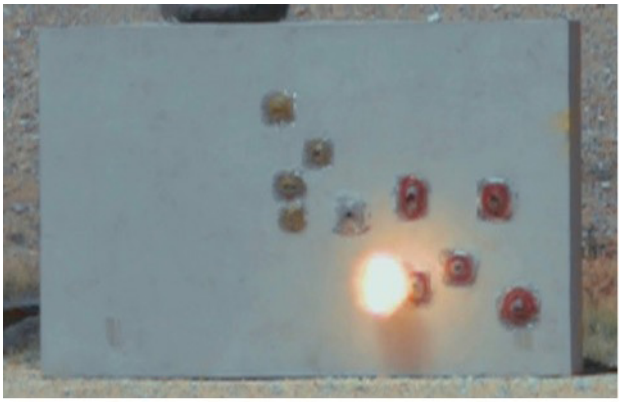
Adventages:
- high protective effect with thin and light design at the same time
- Reinforcement during operation
- Short downtimes due to use
- No additional loads on the existing structure
- Absorption of the largest dynamic effects
- Sustainable solution

Certificates:

The blast and bombardment tests as well as impact and penetration tests were carried out at certified test centers in Germany, European partner countries and the USA.

2.2 Bullet and breakthrough resistance

Bullet resistance:
The close-meshed, spatial micro-reinforcement of DUCON technology enables high resistance to bullets. With a component thickness of only 10 cm, the high resistance class PM9 (FB7) is already met. In addition, the building material guarantees protection against multihit bullets. Only local damage occurs. Bullet resistance was determined for all bullet classes of VPAM PM 2007 to PM14.



Picture: Firing tests with 12.7mm x 112mm hard core bullet incl. incendiary composition (API)

Breakthrough Inhibition:
Breakthrough resistance is a parameter for the resistance of a building component to the impact of tools in accordance with a crime catalog. DUCON meets the highest break-through resistance class RC6 according to DIN EN 1627 from a component thickness of 7.5 cm.

Image: e.g. Oxygen lance > 4.000°C

Breakthrough attempt after gating

2.3 Explosion protection

DUCON concrete already meets the highest safety requirements with only very small component thicknesses. The explosion protection of DUCON was proven in tests with contact charges. Whereas with reinforced concrete – despite higher strengths – smooth blast penetrations with debris throw were observed, with DUCON, on the other hand, only a blast impression without debris throw was produced. Thus, DUCON continues to provide complete protection after blasting.

DUCON technology is mainly used for explosion protection in walls and masonry in new and existing buildings. Due to the slenderness of the components, facade constructions are also possible. The building material has already been used to successfully protect several vulnerable infrastructures such as public facilities, embassies, data centers and nuclear power plants.

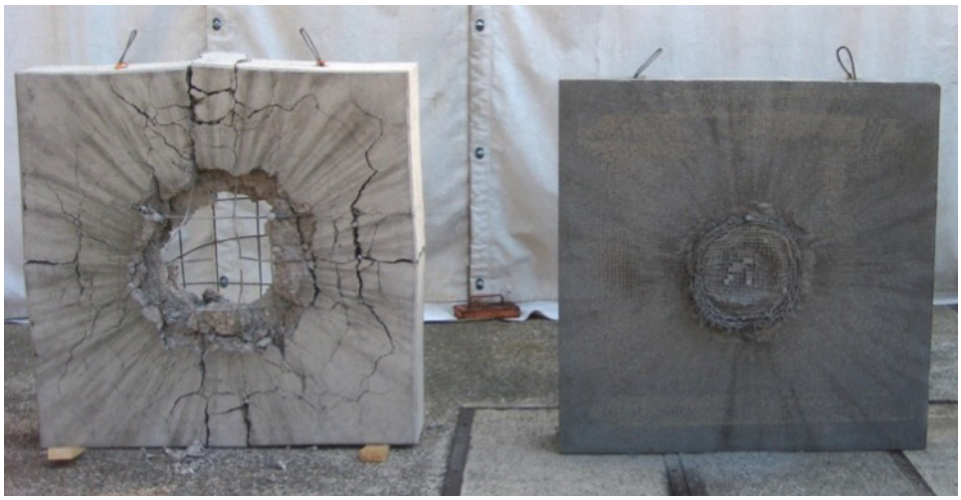


Image: Reinforced concrete with bullet penetration+debris throw vs. DUCON with local damage, no penetration.

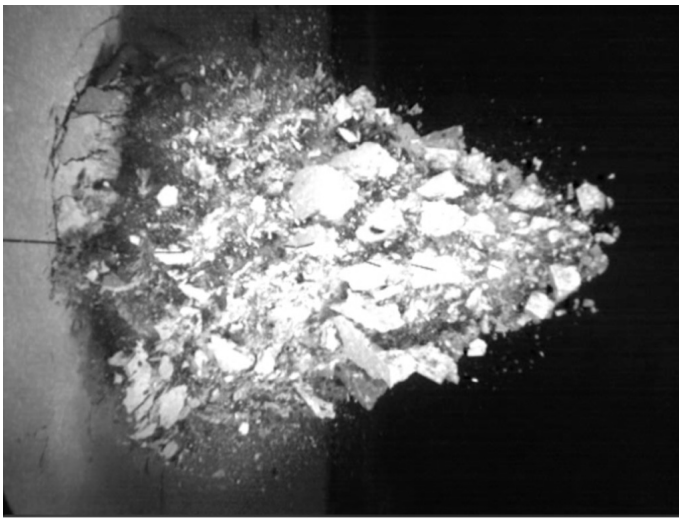


Image: Reinforced concrete failure

Rear: DUCON vs. reinforced concrete (right)

Protective walls / protective facades

Various protective walls made of DUCON were used to secure endangered facilities such as embassies and community centers in Europe and in various crisis areas. Permanently installed walls as well as temporary mobile walls were executed.

Image: protective wall against explosion, protective wall of german embassies

Function: Complete protection against explosions (long-range, short-range and contact detonation)

Reference projects: Explosion protection walls One World Trade Center, New York
Protection wall of a German embassy (Kabul etc.)
Deutsche Bahn main station Frankfurt (2.500m2)

Image: Facade World Trade Center, NY

Protective wall endangered facility, Germany

Support sheathing

DUCON concrete, in the form of a sheathing, not only increases the resistance of reinforced concrete columns to explosion and impact, but also to the effects of earthquakes.The thin sheathing with DUCON prevents the reinforced concrete from breaking away as a result of explosion and earthquakes, thus ensuring the stability of the building structure. This makes it possible to protect high-rise buildings against "progressive collapse".

Sheathing and column reinforcements can be implemented in new and existing buildings as precast elements or in-situ concrete. Column reinforcements with DUCON are also very economical due to the short retrofit periods.

Image: Column reinforcement for explosion, impact and earthquake protection.

Function: "All in one"
Reinforcement of an existing column to increase the load-bearing capacity, impact, explosion and earthquake protection

Reference projects: European Central Bank ECB Frankfurt, GSA Building Washington, Hoch2 Vienna

Explosion protection + debris protection

In addition to protective measures against explosion and impact such as protective walls, explosion-proof facades, column sheathing or shelters, DUCON is also used as a reinforcement solution for floor slabs for debris protection. Here, DUCON is used either as a concrete layer on top of or below existing slabs as a kind of safety net and explosion resistance for building parts above or below.
An exemplary scenario is a car bomb in an underground car park with a public space above the parking level.

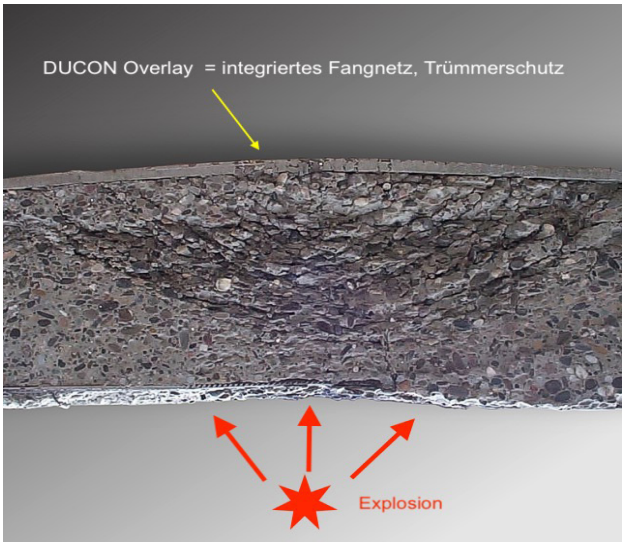


Image: DUCON overlay as a catch net

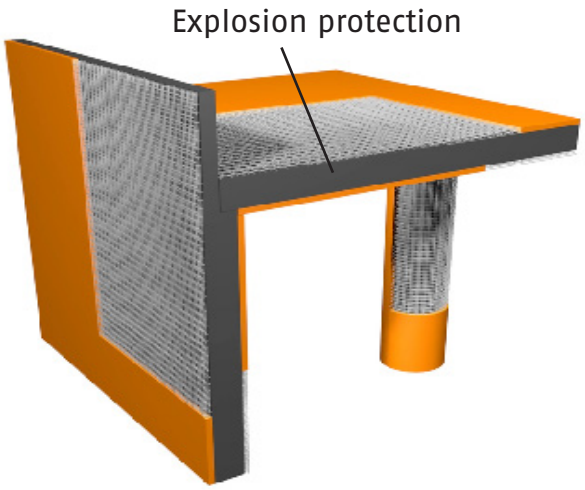


Image: Overlay as explosion + debris protection

Function: Explosion + debris protection against bombs
e.g. car bomb in underground car park and protection of areas above it

Reference projects: High-security data centers, technical rooms TV transmitters, server rooms

DUCON-Security	Planned protective measure
• No demolition of the existing ceiling required • Only replacement of the existing screed = low additional load no change in door heights • Cost-benefit factor: loss of use not decisive here, but effective protection (anti-terrorism) • Additional debris protection fulfilled	• Demolition of the storey ceiling • New construction of a thicker reinforced concrete ceiling = higher weight • New additional loads require additional column reinforcement • Possible debris throwing of the concrete pieces are not prevented • Prolonged loss of use

2.4 Application examples

DUCON-Security can be thermally activated in addition to the functions described under 2.2 to 2.3. Due to the patented structure by means of the integration of capillary tube mats into the micro-reinforcement, the following functions can be achieved due to the thermal conductivity of the thin DUCON layer:

- Protective plates and walls
- Bridge Armor (Critical Infrastructure Protection)
- Security Container (Explosion, Bombardment, Breakthrough)
- Cooling surfaces (heat exchanger)
- Beschuss- und explosionshemmende Sicherheitsschleusen (d = 100mm)
- Panic Room (monolithic, d = 100mm)

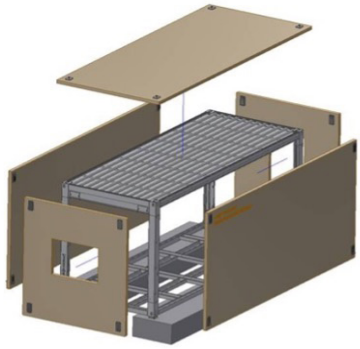


Image: Security-Container | Panic Rooms + Shelters | Security gates

Function: Vulnerable shelters
Reference projects: Protective container Chemical industry, Panic Room NATO, Locks National BankFloor area Nordhausen (Germany)

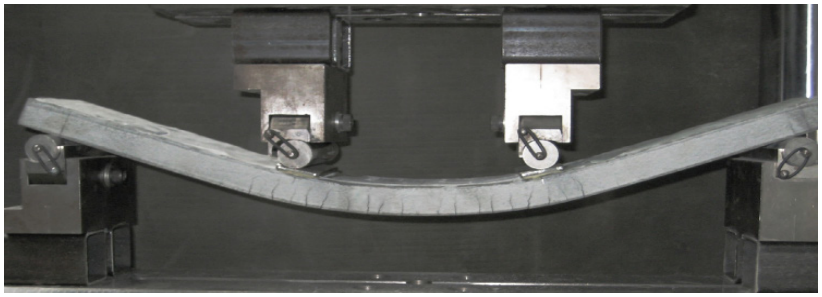
3. References

The following references are examples of the versatility of applications for the protection of critical infrastructure and vulnerable facilities. DUCON as anti-terror concrete and protective measure against accidents and natural disasters.

World Trade Center	*New York, USA*
German Embassy	*Kabul, Afghanistan*
European Central Bank	*Frankfurt, Germany*
JFK Airport	*New York, USA*
GSA Building	*Washington D.C., USA*
High Security Data Centers	*Europe*
German general consulate	*France*
LNG Terminal	*Southeast Asia*
Daimler Benz Production Plant	*Europe*
Philharmonic Opera Hall	*Hamburg* Germany
Tappan Zee Bridge,	*USA*
Nuclear Power Plants	*Germany, USA*
Panic Room	*NATO*
Police Station	*New York, USA*

4. Technical data

Description: Self-compacting micro-reinforced high-performance concrete = Spatial micro-reinforcement + Ultra-high-strength concrete



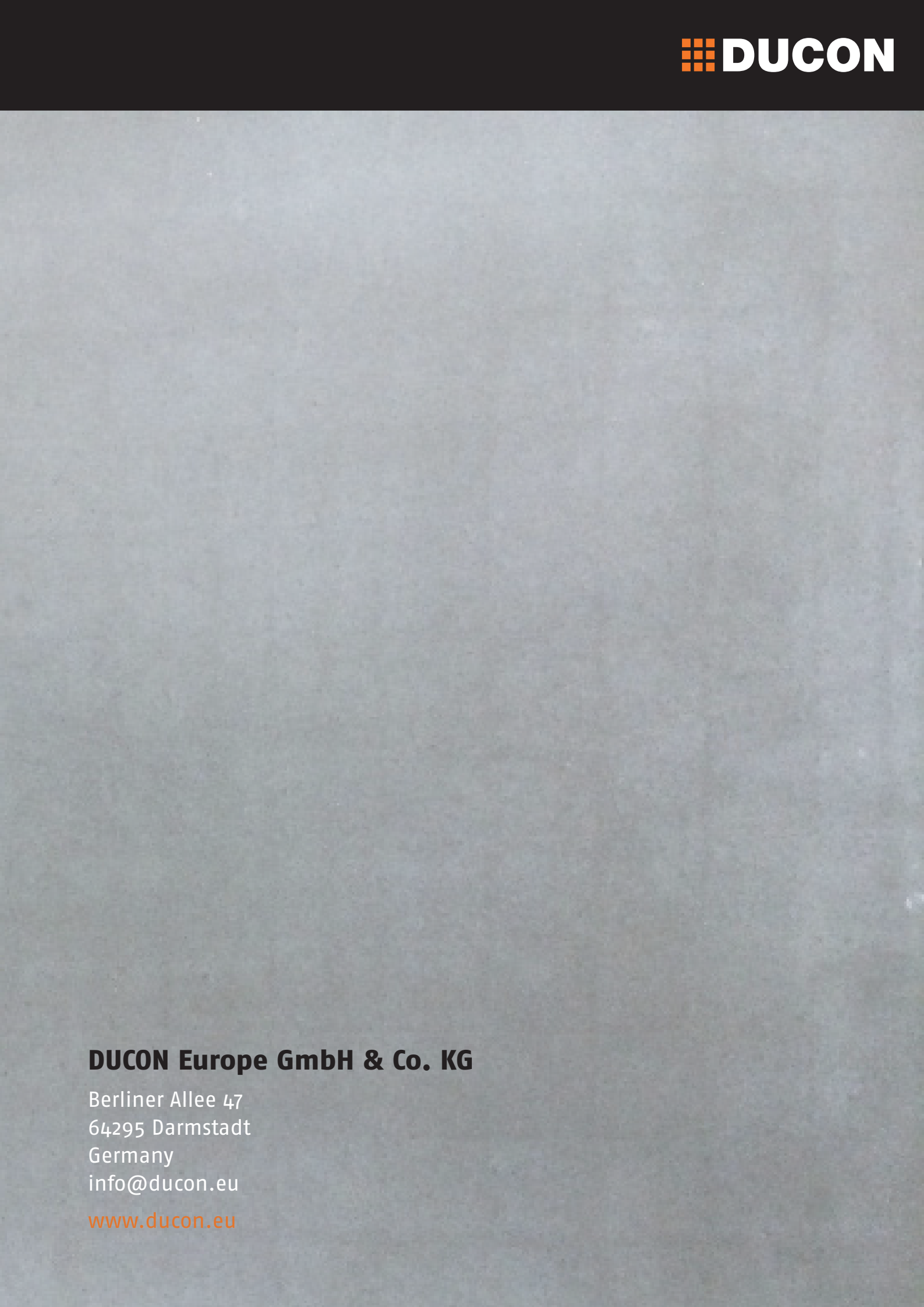
Protective effect: At least equal protection at < 50% of the structural thickness and weight of reinforced concrete (equivalent to 4 to 9 times the performance of DUCON vs. Stb) In addition, no debris shedding

Technical data:

Compressive strengths:	100 – 200 N/mm²
Flexural strengths:	20 – 75 N/mm²
Centr. tensile strengths:	9 – 20 N/mm²
Shear capacity:	3 – 16 N/mm²
Modulus of elasticity:	> 38.000 N/mm²
Bulk density:	25 KN/m³
Component thicknesses:	ab 10 mm
Conductivity:	Earth leakage resistor 1,5 < 1000, DIN 61340-4-1
Ductility grade:	> 8 (Extremely ductile)
Shrinkage:	0,5 – 0,6 ‰(without micro reinforcement: 0,9‰)
Fracture energy:	Gf = 50–80 kN/m (unreinf. concrete 0,1–0,15 kN/m)
Bullet resistance:	FB7: FMJ PB HC bei d = 8 cm (DIN EN 1522)
	FB13 mit d = 10-15cm
	FB14 mit d = 15-20cm
Burglar resistance:	RC6 mit d = 7,5 cm (DIN EN 1627)
	RC5 mit d = 5,0 cm
Explosion protection:	> 1,0 bar bei d = 6 cm (endangered facility)
	> 10 bar msec Impulse bei d = 6 cm

More features: Extremely ductile, i.e. large deformability High load-bearing capacity, high impact strength, high energy absorption High durability, crack width limitation High abrasion resistance, high freeze-thaw resistance Electromagnetic shielding (Faraday cage) Good thermal conductivity and storage capacity, electrical conductivity Multifunctional, adjustable material properties

Production: Installation of the spatially Micro-reinforcement with subsequent mortar infiltration Modular system ensures simple, fast and economical execution



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