KOSTEEL

Steel Fiber Reinforced Concrete Slab

BUNDREX®

SMART SOLUTION FOR
ALL YOUR REINFORCEMENT

CONTENTS


Steel fibers manufactured by Kosteel are dispersed into a concrete mix to provide a multidimensional reinforcement.

Kosteel is in the process of investing in more advanced manufacturing equipment which will help to increase manufacturing capability and help to expand into the Korean domestic as well as the global steel fiber market

CORPORATE HISTORY

2013~

BE READY THE GREAT KOSTEEL

- 2014.12 Kosteel was inducted into the Hall of Fame of the Korea Idea Management conference.
- 2013.01 PREPARING THE GREAT KOSTEEL

61.5% Sales from Global Market!

- Acquired Quality Certifications in each country in which we do business
- Regional sales executives spanning Europe, North America, South America, Oceania and Asia
- Set Kosteel Vina(Plant) in Vietnam as the cornerstone of an active overseas sales platform
- Established a management system targeting the global market and customers

2006~2012

Jump For Growth

- 2010 Acquired ISO9011 / CE / JIS Certifications
  Received the 'President's Award' at the 17th Business Innovation Awards
  Received the '2010 Korea Management conference Award,' for second consecutive year
- 2009.12 Received the '2010 Korea Management conference Award' (The best innovation leadership)
- 2007.10 Completed renovation of the second wire rod production line

Continual and Steady Growth through Innovation

- Building systematic management and pursue innovative workforce through various reformation activities.
- Involved in continuous improvement in the production line through installation of modern high capacity manufacturing equipment.
- Technology / Material Innovation through Institutional Technology Research, Industry-Academic Cooperation, and Rolling Mill.
- Increased production and quality by providing management and training to staff.

2000~2005

Innovation for growth

- Established the KOSTEEL VINA in Vietnam
- Appointed Mr. Park Jae Chun as the chairman of KOSTEEL Group

1991~1999

Build up Growth Energy

- Received Won the '10 Milion Dollar Export Tower' (KITA/Prime Minister)
- Aquired KS Certificate for Low Carbon Steel Wire (KSD 3552)
- Opened Pohang Plant 2 for the Secondary Steel products

1977~1990

Birth of KOSTEEL

- 1988.02 Acquired KS Certification for Low Carbon Steel Wire Rod(KSD 3554)
- 1987.09 Expanding Kosteel Pohang Plant 1 production line
- 1984.06 Completion of Kosteel Pohang Plant 1 with 2nd rolling mills for the primary wire rod products
- 1981.04 Upgraded completion of Kosteel Pohang Plant 1 with rolling mills (Wire Rod)
- 1980.04 Completed TANDEM type rolling mills for Wire Rod products in Kosteel Pohang Plant 1
- 1977.03 Establishment of KOSTEEL Co., Ltd

Kosteel Fulfills social responsibility based on honesty and trust

- Safe and eco-friendly production, which meet industry standards.
- Quality assurance and test reports for each product
- Compliance with rules and principles, with an emphasis on trust and cooperation

KOSTEEL Co., Ltd, a company that has made Korea strong, is heading toward the world with its new Steel Fiber, BUNDREX®

Smart solution for all your reinforcement

BUNDREX® HISTORY

2019~

- 2019. 01 Participated in World of Concrete (Las Vegas NV, USA)
- 05 Participated in World Tunnel Congress (Naples, Italy)
- 06 Participated in Rapid Excavation & Tunneling Conference (Chicago IL, USA)
- 10 Registered patent for New shaped Arch-Type Steel Fiber (USA)

2016~2018

- 2016. 02 Registered patent for New shaped Arch-Type Steel Fiber (Korea)
  Participated in WOC (World of Concrete) (Las Vegas, USA)
- 04 Participated in World Tunnel Congress (San Francisco CA, USA)
- 12 Relocation of Gwangju export production line to Kosteel Pohang Plant 2

- 2017. 01 Participated in World of Concrete (Las Vegas NV, USA)
- 03 Applied patent for New shaped Arch-Type Steel Fiber (USA)
- 06 Participated in World Tunnel Conference (Bergen, Norway)
- 2018. 01 Participated in World of Concrete (Las Vegas NV, USA)
- 05 Participated in World Tunnel Congress (Dubai, UAE)
- 06 Participated in North American Tunnel Conference (Washington DC, USA)

2011~2015

- 2011. 12 Merger of KOSTEEL
- 06 Acquired CE Certification (R Class)
- 10 Development of Concrete floor slab reinforcement design program
- 12 Acquired KS Certification for concrete steel fiber

- 2015. 02 Participated in World of Concrete (Las Vegas NV, USA)
- 05 Acquired Environmental Management Certification (ISO 14001)
- 05 Participated in World Tunnel Congress (Dubrovnik, Croatia)
- 11 Relocation of Gwangju Domestic production line to Kosteel Pohang Plant 2

2006~2010

- 2006. 02 Registered patent for Steel Fiber glue and manufacturing method
- 2009. 08 Completed Fire Resistive performance test for high-strength concrete (60, 80MPa)

- 2010. 06 Acquired CE certification
- 07 Acquired ISO 9001: 2008 certification
- 08 Completed Fire Resistance performance test for Hybrid Fiber segment (KSF 2257-6.7)

2001~2005

- 2001. 10 Established STEELFIBER KOREA
- 2002. 04 Registered design for Concrete reinforcement steel fiber
- 2003. 02 Completed Laboratory and Kosteel Pohang Plant 2 building

- 2004. 03 Expand wire drawing machine line
- 07 Registered BUNDREX® Trademark
- 2005. 12 Completion of STEELFIBER KOREA (Kosteel Pohang Plant 2)


BUNDREX
SMART SOLUTION
FOR ALL YOUR
REINFORCEMENT

Bundrex, which combines the best steel fiber technology with stability and affordability, is widely used as a structural reinforcement for various floor slab concrete structures in civil engineering and building construction.

BUNDREX®

BUNDREX® is an ideal concrete reinforcement which shifts the properties of concrete from brittleness to ductility, and increases toughness and resistance to cracking by drying shrinkage and Plastic shrinkage

Steel Fiber

Steel Fibers are added to the concrete mix to provide multidimensional reinforcement, and is used to replace rebar or mesh.
BUNDREX® is the No. 1 steel fiber brand in Korean market, and has been recognized for its technology in the global market thanks to its safety and cost-effectiveness.

Product

End-Hooked Fiber

Standard type steel fiber with its quality and performance

Arched Fiber

Arched Fiber, a patented steel fiber, increases the performance of concrete by up to 20% compared to conventional steel fiber products.

BUNDREX PRIME

The recently developed Prime series has extremely high tensile strength, enabling higher concrete performance.

production process

KOSTEEL has a one-step production process from wire rod to the steel fiber BUNDREX® thanks to holding Korea's leading drawing technology, and has the No. 1 share in the Korean market due to its technological superiority and cost competitiveness.

Heating Furnace

Rough Rolling

Rolling Mill

Cooling

Straightening and Gluing Line

Bobbine Line

Drawing Line

Wire Rods

Heatting Line

Cooling Line

Cutting Line

Packing

SFRC

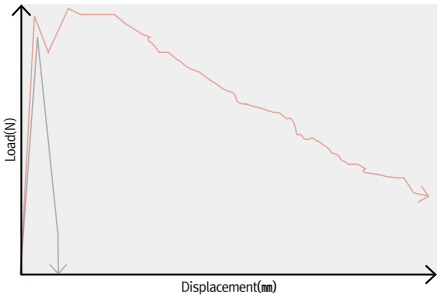
Steel Fiber Reinforced Concrete

Adding Bundrex steel fibers to the concrete mix helps give the concrete a higher tensile strength, together with improving flexural toughness and crack resistance.

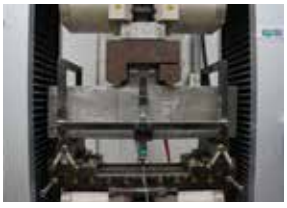
Feature

- Increases the flexural toughness, tensile strength, shear resistance, flexural resistance, fatigue resistance and flexibility of concrete
- Helps control plastic shrinkage cracks
- Helps reduce maintenance cost by improving concrete durability and corrosion resistance
- Reduces the cross-sectional thickness of concrete by improving its physical properties
- Enhances bond strength of concrete through the uniform dispersion of steel fibers
- Increases stability with multidimensional reinforcement inside concrete
- Helps reduce overall costs by eliminating placement of rebar or mesh

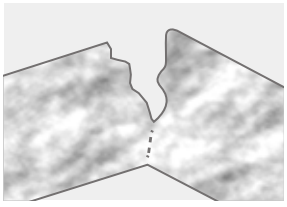
Changes in SFRC Properties Containing **BUNDREX**®



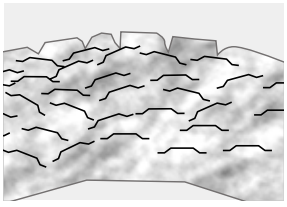
Concrete Properties	BUNDREX® Effects
Modulus Rupture	Increased by up to 3 times
Shear Strength	Increased by up to 2 times
Torsional Strength	Increased by up to 2 times
Fatigue Resistance	Increased by up to 1.8 times
Abrasion and Corrosion	Increased by up to 1.4 times
Shock Absorption	Increased by up to 15 times



Flexural Test



Normal Concrete(Brittle Fracture)



BUNDREX Reinforced Concrete (Ductile Fracture)

Applications

Shotcrete

- Reduces shotcrete thickness
- Protects exposed surface immediately after excavation to prevent collapse
- Reduces workforce (no rebar and mesh assembly required)
- Reduces work time (no rebar assembly required)

Floor Slab

- Reduces work time due to its high workability
- Reduces slab thickness with multidimensional reinforcement
- Increases crack, impact and wear resistance
- Increases the service life of a structure

PC

- Helps accelerate schedule by reducing or eliminating rebar and mesh installation
- Helps reduce cracking while adding durability to the concrete
- Enhances fire retardant performance through the use of steel fiber reinforcement
- Increases cost efficiency

SFRC

Floor slab method

Steel fiber reinforced concrete, which was widely used for shotcrete, is now widely used for floor slabs and precast.
High quality SOG (Slab On Grade) and the SOP (Slab On Pile) steel fiber reinforced concrete floor slab method is applied on various sites in the world.

Advantages

Constructability

- Accelerates schedule by eliminating rebar and mesh placement
- Able to use large laser screed equipment

Quality

- Achieves a high level of ground top smoothness
- Helps control cracking better the rebar concrete method

Maintenance

- Reduce frequency of defects that must be remedied due to its excellent shock resistance, fatigue strength, and wear resistance

Cost-effectiveness

- Reduces labor costs, as no reinforcement assembly process is required
- Reduces construction cost due to shortened construction period
- Reduces cost of concrete by decreasing thickness of slab

Applications

Can be applied to floor slab construction of building and civil engineering structures such as factories, warehouses, container terminal, gas stations, residential foundation slabs and airport taxiways.

Plant

- **Site Name : Kia Mobis Mexico Plant (Mexico)**
- Slab Thickness : 250 mm
- Concrete Strength : 27 MPa
- Steel Fiber Input : 20 kg/m^3

Warehouse

- **Site Name : CUMMINS Warehouse Project (India)**
- Slab Thickness : 250 mm
- Concrete Strength : 30 MPa
- Steel Fiber Input : 25 kg/m^3

Gas Station

- **Site Name : Caltex Truck Stop (Australia)**
- Slab Thickness : 200 mm
- Concrete Strength : 24 MPa
- Steel Fiber Input : 25 kg/m^3

Residential Foundation Slab

- **Site Name : Lakeside Park for Persimmon Homes (UK)**
- Slab Thickness : 200 mm
- Concrete Strength : 21 MPa
- Steel Fiber Input: 40 kg/m^3

Airport lanes

- **Site Name : McCarran International Airport (USA)**
- Slab Thickness : 400 mm
- Concrete Strength : 30 MPa
- Steel Fiber Input : 50 kg/m^3

Container Terminal

- **Site Name : Algeciras Harbour Project (Spain)**
- Slab Thickness : 320 mm
- Concrete Strength : 30 MPa
- Steel Fiber Input : 35 kg/m^3

SFEED-Pro

Steel Fiber Enhanced Engineering Design Program

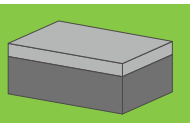
SFEED-Pro, developed by KOSTEEL, is a unique design program that provides customers with accurate, modern, structural design solutions, and has been certified by the Korea Institute of Construction and Structural Technology (KSEA) for the superior performance of BUNDREX steel fibers.

Species

SFEED PRO
Steel Fiber Enhanced Engineering Design PROgram

SFEED-Pro-GSS

Grade Supported Slab

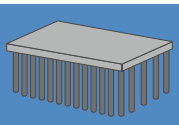


SFEED-Pro-GSS is design program for SOG. The often times, the Kosteel design allows for a reduction in the lab thickness and steel fiber usage can be calculated based on the load and ground conditions.

- Design Criteria: TR-34, ACI 360
- SFRC Performance Parameters: $R_{e,3}$

SFEED-Pro-PSS

Pile Supported Slab



SFEED-Pro-PSS is an SOP design program used in conditions where the ground is very unstable to support concrete slabs. BUNDREX PRIME has been developed to solidify slab under conditions of pile support with the appropriate amount of steel fiber.

- Design Criteria: TR-34, ACI 360
- SFRC Performance Parameters: CMOD

Feature

- Enter various variables for requirements such as materials, loads, safety factors and environmental conditions
- Case simulation by varying slab thickness and concrete strength
- Perform case-by-case safety check and economic analysis through the above process
- Apply flexural toughness value reinforced with **BUNDREX**® steel fiber

Certification Status

Certifications

'KSEA(Korea)'
KOSTEEL Fiber Reinforced Concrete Design and Product

'KS(Korea)'
KOSTEEL Steel Fiber Product and Factory

'CE(Europe)'
KOSTEEL Steel Fiber Product and Factory

'ISO9001'
KOSTEEL Steel Fiber Factory

'ISO 14001 certification'
KOSTEEL Steel Fiber Factory

'ASTM(USA)'
KOSTEEL Steel Fiber Product

'Patent(Korea)'
New Shape Steel Fiber

'Patent(USA)'
New Shape Steel Fiber

SFRC SOG

SMART SOLUTION
FOR ALL YOUR
REINFORCEMENT

BUNDREX's SFRC SOG is the standard that offers much more in the way of economic advantages, such as shortening the construction period, maintaining increased durability and reducing repair costs.

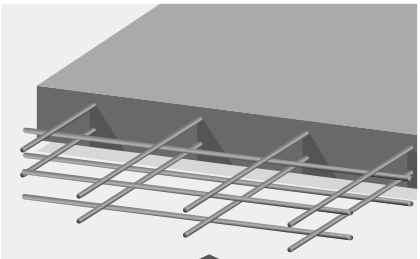
SFRC SOG Method

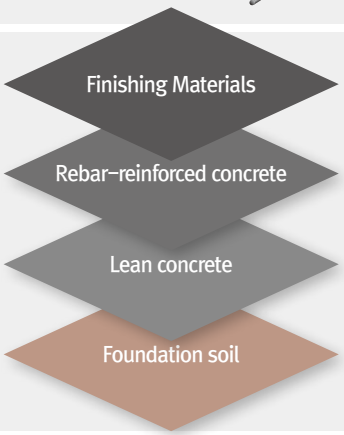
Steel Fiber Reinforced Concrete Slab On Grade

Method to make concrete slab by reinforcing steel fiber on the ground which has secured bearing capacity The excellence of the construction method has been proven, and it is applied to various civil engineering and building construction site in the world.

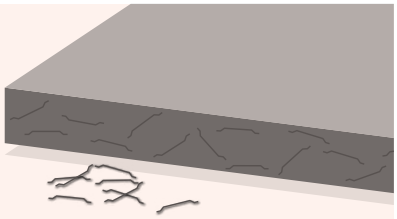
Advantages

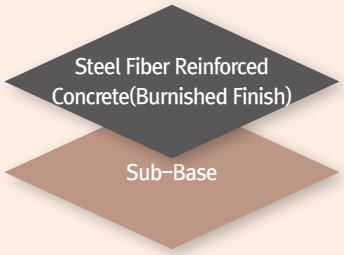
Existing rebar-reinforced concrete (RC) method





Steel Fiber Reinforced Concrete (SFRC) Method





Reduced thickness by **20**%/Reduced construction period by **40**%/Reduced cost by **20**%

Constructability

- Reduce construction time by omitting the rebar installation process
- Able to construct through fast-track approach using Laser Screed equipment
- Typically able to pour up to 2,500m2 per day
- Reduced finishing time through the use of equipment such as floater, trowelling machine and burnishing systems

Quality

- Increased load balancing capacity due to multidimensional reinforcement through the dispersion of steel fiber
- High flatness and levelness is possible due to laser screeding process
- Increased surface hardness due to burnishing
- Increased crack suppression effect compared to RC method (multi-dimensional reinforcement)

Maintenance

- Decrease in defects due to increasing abrasion resistance, impact resistance and fatigue strength for steel fiber reinforced concrete

Economic Efficiency

- Reduced slab thickness due to multidimensional reinforcement
- Rebar installation labor can be omitted and construction period reduced due to simple construction process
- Lowered maintenance cost thanks to its excellent durability

Comparison of Conventional RC vs SFRC method for SOG

The SFRC method can reduce slab thickness under the same design conditions, reducing construction cost by 20% and construction period by 40% compared to the RC method.

Structural Design Comparison

OOO New Construction	
Purpose	• Industrial Building • Factory
Basic Design	• RC FLOOR • Epoxy Paint
Changed Design	• SFRC FLOOR • Permeability surface reinforcing agent
Scope of Application	• For all of 1st Floor
Area	• About 15,000m²

Classification	R.C – SLAB	S.F.R.C – SLAB
Coefficient of subgrade reaction for foundation	0.05 N/mm³	0.05 N/mm³
Concrete Strength	24MPa	24MPa
Live Load	30 kN/m²	30 kN/m²
Wheel Load	2.5 kN/wheel	2.5 kN/wheel
Design Method	Elastic Design (Strength design method)	Plastic Design (Limit state design method)
Slab Thickness	250 mm	200 mm
Steel fiber input volume	–	25 kg/m²
Rebar reinforcement volume	2-HD13@200(SD 400, upper & lower, two-way)	–
Cost of construction	100	80

Quality comparison

Classification	R.C – SLAB	S.F.R.C – SLAB
Construtions	 Rebar installation involves a great deal of time, and involves the use of pumps to protect placed rebar.	 This requires no rebar installation, as the steel fiber reinforced concrete can be placed directly from a concrete mixer truck
Flatness	• Must be checked manually during construction. • Less than FM3 from TR-34 (poor)	• Can operate laser Screed (automatically checks for flatness). • More than FM2 from TR-34 (good)
Crack	 Unable to reinforce total area of slab due to 2-dimensional reinforcement ➔ Durability and usability is poor, with many cracks	 Able to reinforce total area of slab due to multidimensional reinforcement ➔ Prevents cracking in order to increase durability and improve usability
Joint	Spalling due to wooden formwork	No spalling due to buried steel formwork
Construction Period	Total construction period 23 days 4 days Sub-Slab Concrete 5 days Rebar Installation 8 days Pouring & Plastering 6 days epoxy finish	Total construction period 14 days 2 days Prepare for placement 8 days SFRC 4 days Placing surface reinforcing agent 40% reduction in construction period

Construction Procedure

It is possible to work easily and in a cost-efficient manner because there is no need for reinforcement placing rebar or welded wire mesh reinforcing, which shortens the construction time and reduces the cost.

1 Plate Bearing Test →

2 Ground Compacting →

3 Vinyl Covering →

4 Install Construction Joint →

5 Concrete Pouring →

6 Laser Screeding →

7 Remove exposed steel fiber →

8 Floating & Trowelling →

9 Burnich and Finish →

Construction Guideline

1. General

In construction of a steel fiber reinforced concrete floor, the ingredients, mixing, mixer and management ofconstruction shall be considered carefully to achieve the required quality.

2. Measuring of ingredients

Measuring and measuring device

1) Each ingredient for steel fiber reinforced concrete floor shall be measured accurately in order to obtain the required quality.
2) The steel fiber measuring method and device shall be approved by appointed technician or engineer before its use.

Measuring of steel fiber

1) Steel fiber shall be measured based on the weight per batch.
2) The tolerence of one weight measuring must be less than 2%.

3. Additives

Adding at batch plant

Use a conveyor belt for adding steel fiber at the batch plant. Measuring steel fiber shall be separated from this procedure.

Adding at mixer truck

Add directly into the hopper of the mixed concrete truck and mix for 2 minutes at maximum rotating speed, then rotate for 1~2 minutes at a low rotating speed to allow the steel fiber to uniformly disperse. Additional mixing time may be required if slump is too small or the amount of aggregates dosage is small.

4. Mixing

General

Sufficient mixing shall be performed to obtain the required quality of steel fiber reinforced concrete for floor.

Mixer

1) Compulsory batch mixer shall be used as the standard mixer.
2) The designated technician or engineer's approval shall be required to use a continuous mixer.

Adding Steel Fiber

When steel fiber is added into the mixer, an appropriate method shall be used so that the steel fiber can be uniformly dispersed in the concrete.

Mixing Period

In principle, the mixing period shall be determined by the test.

5. Delivery

General

1) Before the start of construction, sufficient plans for transportation and casting should be approved by the chief engineer.
2) Steel fiber reinforced floor concrete should be transported in small quantities and cast immediately to minimize material separation.

Transporting Machines

1) Mixer truck for transport steel fiber reinforced concrete must be designed to unload concrete easily.
2) In the model selection when using a concrete pump, quality of the steel fiber reinforced floor concrete, casting places, including the amount casting must be considered.

6. Pouring

Pouring steel fiber reinforced floor concrete

1) When placing steel fiber reinforced floor concrete, the pouring equipment and forms should be cleaned in advance to prevent frommiscellaneous substanceentering the concrete. Areas in where moisture might be absorbed from concrete should be wetted in advance.
2) Steel fiber reinforced floor concrete should not be moved back after being casted in form.
3) Steel fiber reinforced floor concrete pouring in one section should be done once

Hardening

Steel fiber reinforced floor concrete should be sufficiently harden immediately after pouring. In principle, a vibrator is used for the hardening.

7. Quality Control of Construction Site

General

1) Concrete ingredients, equipment, construction method, concrete structure after the construction, etc. shall be inspected in order to ensure that the quality requirement for steel fiber reinforced concrete floor is met.
2) Inspection shall be carried out based on the criterion which verifies that a concrete structure is constructed according to the quality requirements. The inspection shall be considered a "Pass" if the result is suitable for the quality requirement criteria.

Managing steel fiber reinforced concrete floor

1) Management of a steel fiber reinforced concrete floor shall be based on the strength, toughness and dosage of steel fiber. In this case, a specimen should be taken to represent the structure of the steel fiber reinforced concrete floor.

2) The test value of strength and toughness for the steel fiber reinforced concrete floor should be based on the average value of 4 specimens taken from the same batch.

Quality inspection of steel fiber dosage shall follow the below table.

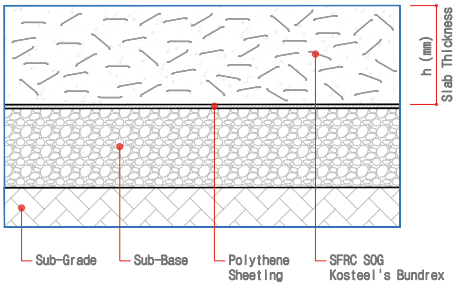
Category	Number or Times	Acceptance Criteria
Steel Fiber Dosage	• At the time of collecting a specimen for strength • When a quality change is observed	Tolerance (%) ±0.5

Quality inspection of cured concrete for flexural strength and toughness shall follow the table below.

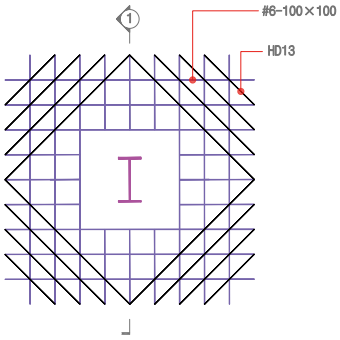
Category	Number or Times	Inspection Criteria
Flexural Strength and Toughness	• At the time of collecting a specimen for strength • When a quality change is observed	Tolerance (%) ±5

Detail Drawing of SFRC SOG

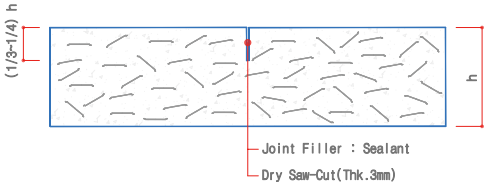
SFRC SOG Section



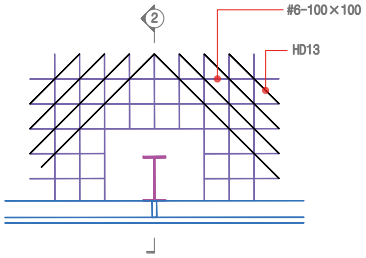
Corner Reinforcement



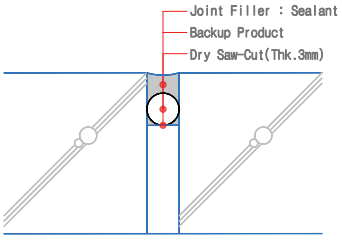
Saw Cut control joint



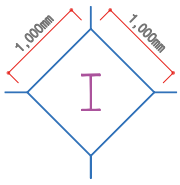
Column Side Reinforcement



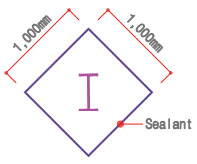
Saw Cut Section Details



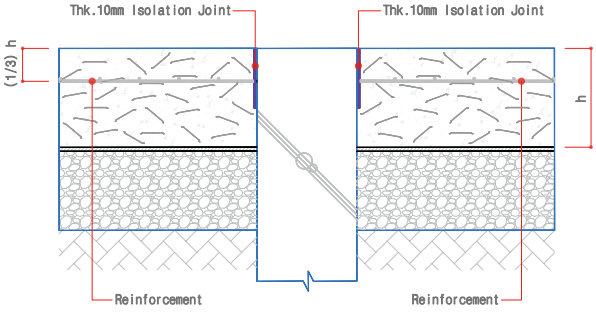
Column Side Saw Cut



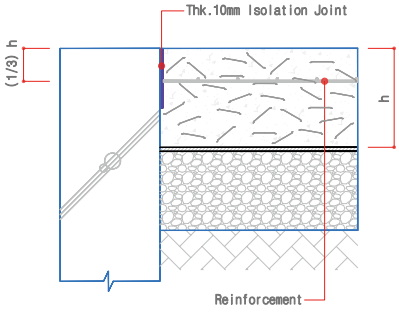
Column Side Saw Cut Caulking



Section ①



Section ②



NOTE

1. Steel Fiber : Kosteel's Steel Fiber Bundrex (KF 80/60, KF 67/60)
2. Steel Fiber Length : 60mm
3. Steel Fiber Diameter : 0.75mm, 0.90mm
4. Steel Fiber Aspect Ratio : 80, 60
5. Design : Kosteel's SFRC SOG Design Program 'SFEED Pro' (TR-34)

SFEED-Pro GSS

SFRC SOG Design Program

The SFEED-Pro GSS program is designed≡ to calculate various loading conditions for SFRC SOG in accordance with the UK's Technical Report 34 (TR-34).

Overview

- Generally, industrial slabs on pile are considered to be non-structural elements, and thus unless there is a specific instruction set to follow, design calculation can be carried out using TR-34 without considering the regional Design Code.
- The SFRC SOG design using 'SFEED PRO' provides the most economical and safe design by analyzing a range of design cases that consider the strengths and thickness of concrete, as well as various sizes and dosages of steel fiber.
- 'SFEED Pro' runs with Re, 3 values obtained from KOSTEEL's steel fiber products (BUNDREX). Any and all design calculations using this program should only use **BUNDREX**® products.

Design Procedure of 'SFEED Pro'

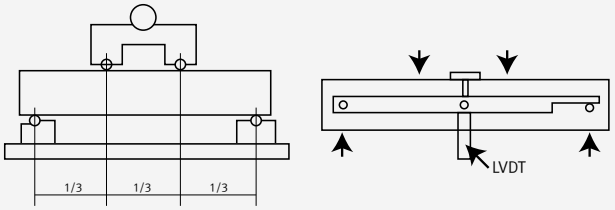
Classification	Input
Material	• Concrete: Designate initial design strength, incremental value, number of cases (*) • Steel fiber: Choose size of Bundrex®
Slab	• Region: Designate number and area of region • Thickness: Designate initial thickness, incremental value, number of cases (*)
Dowel	• Enter loading condition at joints • Enter load transfer rate (%)
Load	• Enter load conditions • Concentrated load, linear load, uniform load • Rack • Uniform • Mezzanine • Fork Lift • Wall • Truck
Safety factor	• Enter safety factor for loads and materials
Environmental Factor	• Enter temperature difference between top and bottom of slab
Sub-base	• FEnter coefficient of friction between slab and sub-base • Enter modulus of sub-grade reaction (k)
Unit Cost	• Enter unit cost for concrete and steel fiber (***)

Design Calculation	Output
Calculate various cases of structural designs by concrete strength (*) and slab thickness (**) based on the given conditions ⇣ Calculate the $R_{e,3}$ values for each case ⇣ Calculate steel fiber dosages for each case with the appropriate $R_{e,3}$ ⇣ Cost analysis based on amounts of concrete and steel fiber (***)	Select the most economical case and provide output of structural calculations for each case

'SFEED Pro' vs Other Program

Classification	Other Program	SFEED Pro
Economic Feasibility Analysis	• No analysis of economic feasibility available • No analysis of economic feasibility function • Unable to provide optimum design case	• Analysis of economic feasibility available • Cost analysis for economic feasibility function available for concrete & steel fiber • Easy to case analysis for optimal design
Convenience of Design	• Only 1 concrete thickness and strength input is allowed • Separate calculation where there is 'no good' design • Long time required for design calculation	• Up to 5 concrete thicknesses and strength inputs are allowed • Recursive calculation available at once with minimum time (up to 25 cases) • Reduce structural design time
KSEA Certification	• Other programs (Bekart, Arcelomithal, and Macaferries) claim to follow the TR-34 guide as a standard for calculation • However, there has been no approval by a qualified third party	• Following TR-34 guide as standard for its calculation • Approval by KSEA, who has the top professional in this field
Details and Specification	• No construction guide or details available • Contractor or design engineers must produce additional specifications or detailed drawings	• Construction guide or details available for SFRC SOG • Provide standard construction specification • Provide convenience to contractor or designer in performing their work

Performance Test



Figrure 1

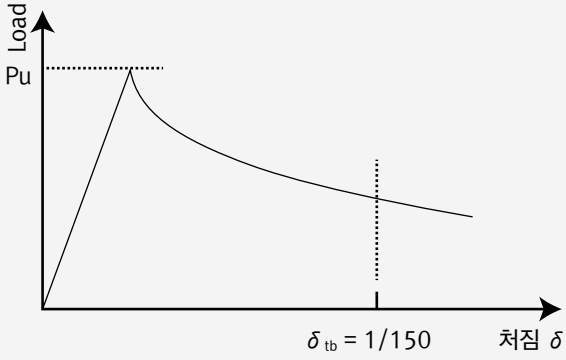
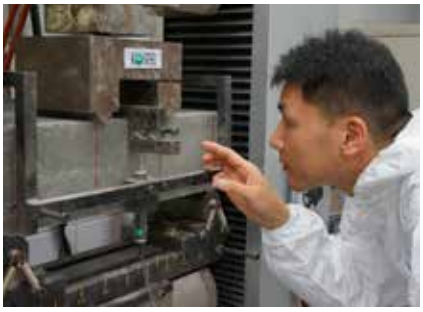


Figure 2

- Four-point loading beam test (figure 1) is conducted based on Japan's JSCE (Japan Society of Civil Engineers) code.
- Then, equivalent flexural strength (fe) and equivalent flexural strength ratio (Re, 3) can be calculated based on the load displacement curve (figure 2) obtained from the test.
- Design formula for TR-34's SFRC SOG is consisted based on the equivalent flexural tensile strength ratio ($R_{e,3}$)

Test Result

Specimen Production



Under Loading Test

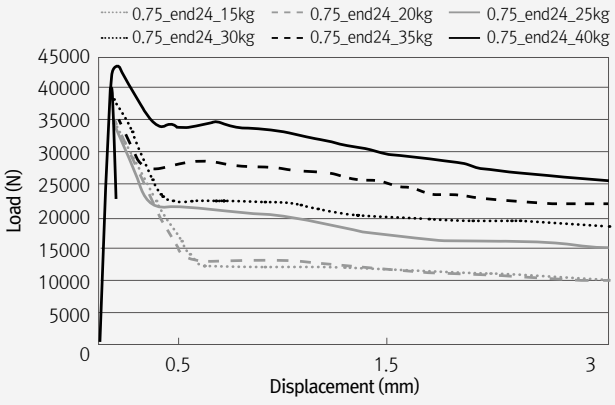
Complete Test

Equivalent Flexural Strength Ratio $R_{e,3}$

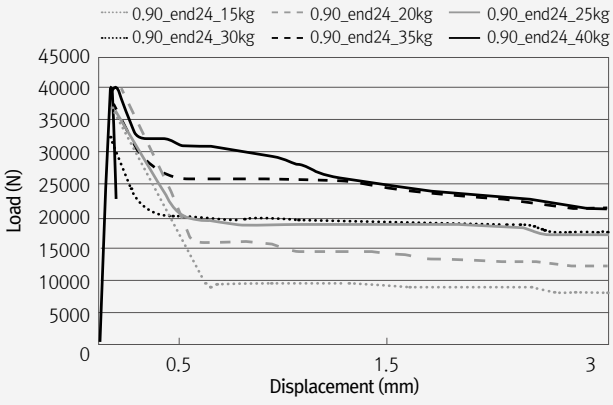
Steel Fiber (**BUNDREX**®)			Dosage (kg/m³)	$R_{e,3}$ (%)
Specification	Lenght (mm)	Diameter (mm)		
KF 80/60	60	0.75	15~40	41~82
KF 67/60	60	0.90	15~40	37~79

Load-displacement curve

KF 80/60



KF 67/60



'SFEED Pro' designs are based on the performance test data ($R_{e,3}$) of KOSTEEL's BUNDREX. Therefore, projects that are designed by 'SFEED Pro' must use BUNDREX and not any other products.

Example of Design Calculation

Project Information

Classification	Contents
Project Name	Steel Fiber Reinforced Concrete Slab on Grade (SFRC SOG) Project
Location.	Seoul, Korea
Construction Period.	2018.10 ~ 2018.12
Design Date	2018.03
Designed by (Company)	KOSTEEL
Designed by (Name)	Mr. Hong Kil-dong

Input value

Concrete

Classification		Contents
Concrete Strength, fck	Minimum Value (MPa)	21
	Incremental value (MPa)	3
	Number of cases (ea)	5
Poisson's Ratio		0.2

Steel Fiber (KOSTEEL BUNDREX®)

Specification	Characteristic Value				Choose
	Lenght, L(mm)	Diameter, D(mm)	Geometry ratio L/D	Tensile strength(MPa)	
KF 80/60	60	0.75	80	1,100	◎
KF 67/60	60	0.90	67	1,050	-

Slab & Joint

Number of design partitions	Area (m^2)	Thickness			Saw Cut Joint			
		Minimum Value (mm)	Incremental value (mm)	Number of Case (ea)	With / Without		Joint spacing (mm)	
					With	Without	X-Direction	Y-Direction
1	10,000	200	25	5	◎	-	5,000	5,000

Load

Rack Load	Wall Load	Uniform Load	Forklift Load
80 kN	60 kN/m	60 kN/m^2	80 kN/Wheel

Summary of Results

Concrete Strength	Slab Thickness	Steel Fiber Dosage
30 MPa	250 mm	20 kg/m^3

Design support site - **308** sites/Site supplied - **134** sites/Quantity supplied - about **6,000** ton

Design support and construction performance

From 2014 to 2020, we provided design support to 308 Domestic (South korea) sites and supplied BUNREX steel fiber products to 134 SFRC floor slab construction sites.

BUNDREX SFRC SOG construction performance

Domestic (South korea)

Design support site - **308** sites/Site supplied - **134** sites/Quantity supplied - about **6,000** ton

- Construction of Sampyo Hwa-sung factory
- Construction of Ssangyong Ciffcon factory
- Construction of Guri Logistics Center
- Construction of MH Pyeonggok Logistics Center
- Construction of Hyuandai Mobis Ulsan factory
- Construction of Gyeongsan Tyco factory
- Construction of Hyorim Gyeongsan factory
- Construction of Icheon, Maegok-ri Logistics Center
- Construction of AK Logistics Center
- Hanwha S-ONE Project
- Construction of Yong-in Bae Bong-ri Logistics Center
- Construction of National Agricultural Cooperative Federation Miryang Logistics Center
- Construction of Sam Shin Chemical factory
- Construction of SungShin Hysco factory
- Construction of Gyeongsan DYC Logistics Center
- Construction of Namyang Nynexmo Hwasung factory
- Construction of Pyeongtaek Chun-il Logistics Center
- Construction of Seo Yi Chun Cha Logistics Center
- Construction of Woojin Industrial Systems Railroad car factory
- Construction of Ilshin textile plant
- Construction of Renault-Samsung Busan Sola generating parking lot
- Construction of Deokpyeong Hu-med Logistics Center
- Construction of Cheonan E-Land Logistics Center
- Construction of Mapei Cheonan factory
- Construction of Mercedes-Benz Parts Logistics Center (Korea)
- Construction of Ulsan Exhibit Convention Center

Renault-Samsung Busan Sola generating parking lot construction

Deokpyeong Hu-med Logistics Center construction

Cheonan E-Land Logistics Center construction

Mapei Cheonan factory construction

Mercedes-Benz Parts Logistics Center construction (Korea)

Ulsan Exhibit Convention Center construction

Global

Office Depot Warehouse (USA)
CUMMINS Warehouse (India)
Nimetech Project (Finland)
Fresenius Medical Care SOG Project (Colombia)
Industrial Slab for Hitachi Fortune Transformer Inc-New Plant (Taiwan)
Kallio Project (Finland)
Thai Drnk Ayuthaya Projet (Thailand)
Thai Summit Eng P3 Project (Thailand)
Isuzu Project (Thailand)
Glory Project (Philippines)
JTI Project (Philippines)

Daimler Colombia Mercedes Benz SOG Project (South America)

Kia Mobis India factory construction (India)

Coca Cola Plant Project (South America)

SFRC SOP

SMART SOLUTION
FOR ALL YOUR
REINFORCEMENT

BUNDREX SFRC SOP available on pile foundations even on low soil bearing capacity and are leading with all aspects of safety and cost.

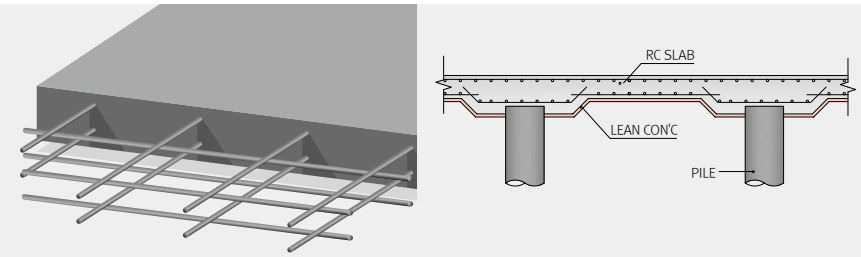
SFRC SOP Method

Steel fiber reinforced concrete floor slab for pile sub-base

The SFRC slab pouring method is applied where it is difficult to secure soil bearing capacity, and a pile foundation is needed due to soft ground.

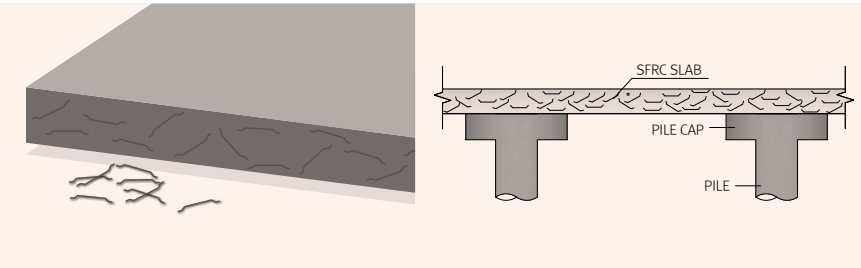
Strengths Advantages

Conventional Rebar-reinforced Concrete (RC) method



Improved Quality / Reduced construction period / Reduced cost

Steel Fiber Reinforced Concrete (SFRC) Method



Constructability

- Reduce construction time by omitting the rebar installation process
- Can be constructed in fast-track method using Laser Screed equipment

Cost-Effectiveness

- Material cost reduced due to skip the process for sub-slab concrete
- Reduced maintenance cost due to multidimensional reinforcement

Quality

- Increased flexural strength of concrete through high tensile steel fiber
- Increased crack suppressing effect compared to RC method (Multidimensional reinforcement)
- Reduced dry shrinkage cracks due to separation of piles and slabs

Overview of Construction Method

SFRC slab pouring method is applied where it is difficult to secure soil bearing capacity, and pile foundation is necessary due to soft ground.

- Recently, warehouses and factory constructions are increasing near port areas and on soft ground.
- Pile foundation is needed to support the load.
- To accomplish this, the slab must also have sufficient strength.
- The application of the steel fiber reinforced concrete floor slab method in pile foundations is growing due to the disadvantage of tying the RC Slab and pile, which involves a lot of cost and time.
- Steel fiber reinforced concrete is required to have a high residual flexural strength to replace rebar reinforcement.
- High tensile steel fibers must be used.

1 External Load Factor Analysis

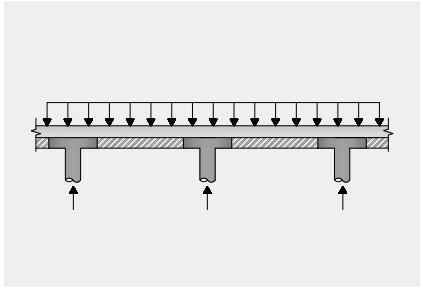
Racking System

Dynamic Load

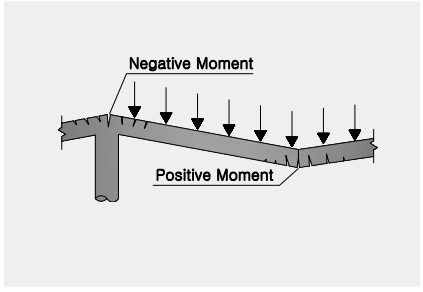
Stock Load

Crack Control

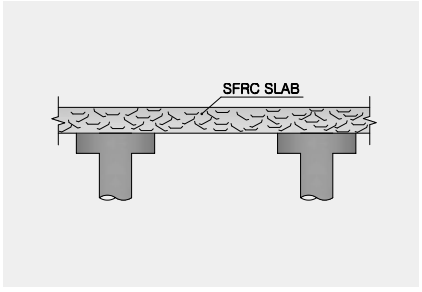
2 SOG SOP Design



Input load



Examine Flexural Resistance



Calculate Steel Fiber Reinforcement

3 SFRC SOP Construction

Pile Ground Reinforcement →

Concrete Pouring →

Flattening Work →

Completed

Comparison of conventional RC vs SFRC methods for Pile Support SOP (Slab on Pile)

Compared to the conventional RC method, the SFRC method enables the construction cost and period to be reduced by omitting the rebar installation and sub-base process.

Structural Design Comparison

OOO New Construction				
Purpose	Basic Design	Change of Design	Range of Application	Area
• Logistics warehouse	• RC FLOOR	• SFRC FLOOR	• For all of 1st floor	• Approx 58,000 m^2

Classification	R.C – SLAB	S.F.R.C – SLAB
Coefficient of subgrade reaction for foundation	Less than 0.05 N/mm^2	Less than 0.05 N/mm^2
Concrete strength	24 MPa	30 MPa
UDL	30 kN/m^2	30 kN/m^2
Wheel Load	80 kN/wheel	80 kN/wheel
Line load	95 kN/m	95 kN/m
Design Method	(Strength design method)	(Limit state design)
Slab Thickness	350 mm	320 mm
Rebar Reinforcement Volume	2-HD19@200(SD 500, upper & lower, two-way)	-
Steel Fiber Dosage	-	40 kg/m^3
Pile Diameter and Spacing	PHC Φ500, 5.5m x 5.5m	PHC Φ500, 5.5m x 5.5m
Pile Head	1.5m x 1.5m	1.5m x 1.5m
Bending Strength	120 kN.m	178 kN.m
Construction Cost (%)	100	80

SFRC Slab Additional Analysis

Classification	R.C – SLAB	S.F.R.C – SLAB
Bending Moment	◎	◎
Shearing Load	◎	◎
Fatigue Load	–	◎
serviceability (Minimum Slab Thickness)	–	◎

SFEED-Pro PSS

SFRC SOP Design Program

The SFEED-Pro PSS program is designed to calculate various loading conditions for SFRC SOP in accordance with the UK's Technical Report 34 (TR-34).

Overview

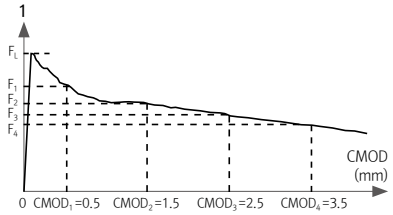
- Generally, industrial slabs on pile are considered to be non-structural elements, and thus unless there is a specific instruction set to follow, design calculation can be carried out using TR-34 without considering the regional Design Code.
- SFRC SOP design using SFEED Pro enables the calculation of concrete strength, slab thickness, steel fiber size and input volume depending on pile spacing and load
- 'SFEED Pro' runs with Re, 3 values obtained from KOSTEEL's steel fiber products (BUNDREX). Any and all design calculations using this program should only use **BUNDREX**® products.

Design Procedure of 'SFEED Pro'

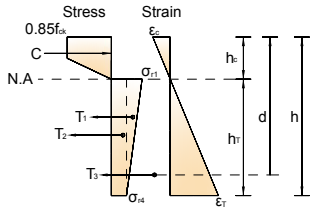
Classification	Input	Design Calculation	Output
Safety Factor	• Enter safety factor for load and material	Apply SFRC CMOD value according to material selection ⋮ Calculate resistance of slab ⋮ Calculate working load related to pile and load ⋮ Evaluate slab usability (Minimum thickness) ⋮ Evaluate safety after comparing resistance, applied load ⋮ Determine optimal design of slab ⋮ thickness and steel fiber specification	Output optimal design review and structure report
Material	• Concrete: Design Strength • Steel Fiber: Choose size of Bundrex®		
Pile	• Pile Spacing • Diameter or width of Pile head		
Slab	• Assume Slab Thickness		
Load	• Enter Load • Enter site loading conditions • Concentrated Load, line Load, uniform Load, dynamic Load		

Flexural Strength Analysis

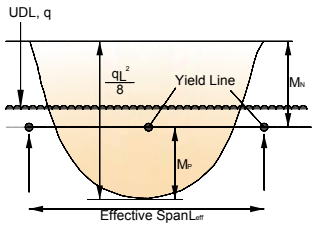
- Steel fiber reinforced concrete allows concrete to have tensile strength through the bridging action of steel fiber, so it can replace existing rebar.
- Flexural strength of SFRC should be calculated based on test results in accordance with BS EN 14651.
- It is determined based on the yield line theory, SFRC SOP structural analysis plastic theory. In this case, the ratio main moment and sub moment before fracture is 1: 1 due to the occurrence of plastic hinge and inelastic deformation after cracking.



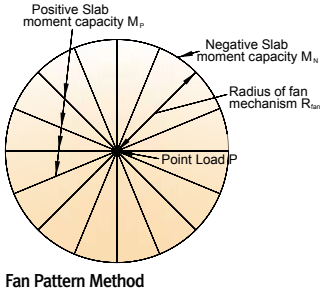
CMOD Test Graph



SFRC Strain and Stress



Folded Plate Method



Fan Pattern Method

Additional Analysis

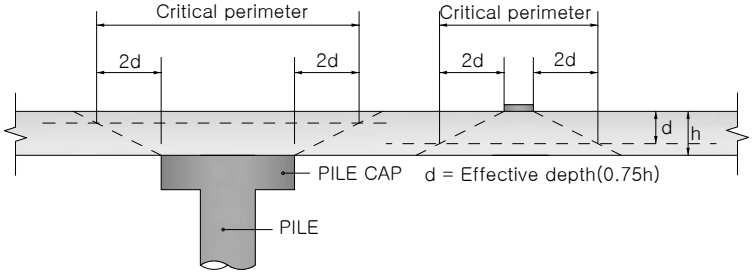
Serviceability (Minimum Slab Thickness)

- The minimum slab thickness is calculated based on the flexural stress of plain concrete to prevent the risk of flexural cracking when working load is applied.
- The working load is examined according to uniform load and line load including self-load based on the TR-34 standard.

Minimum Thickness, H_{min}	• $H_{min} = 21*L_{eff}\,(q / f_{ctd})^{0.5}$	• q = UDL • q = 1.5*Line Load / L_{eff}

Punching Shear Analysis

- Punching shear is calculated based on shear strength on the pile head or slab area with factored load to determine stability against external forces.
- Shear strength of steel fiber reinforced concrete includes the shear strength of plain concrete and added shear strength from steel fiber.
- The dangerous shear range is considered to be twice the slab effective depth (d).



Dangerous shear range of slabs

Punching Shear Capacity	• $V_{Rd,c}=0.035k_s*1.5*f_{ck0.5}$	⟶ • Plain Concrete
	• $V_f=[0.12(f_{r1}+f_{r4})/2]/2$	⟶ • Steel Fiber
	• $P_p=(V_{Rd,c}+V_f)u_1d$	⟶ • Residual Shear Strength

Evaluation of fatigue stress by dynamic load

- Truck or forklift loads have millions of dynamic fatigue effects on slab.
- Long-term fatigue reduces the performance of concrete slab, thus reducing the residual flexural stress of the slab by calculating the stress reduction factor (F).

Fatigue Dynamic Strength	• $M_{dyn}=F \times [(0.2\ W_a\ L_{eff}) / WB + 0.6L_{eff}]$	• F (Dynamic Load Reduction Factor) 0.4~0.8)

Performance Test

Test Method (BS EN 14651).

- Flexural tensile test is performed on a specimen of Notched Beam in accordance with the British BS (British Standard) (Figure 1).
- Then, maximum flexural strength and residual flexural strength ratio can be calculated based on the load displacement curve (figure 2) obtained from the test.
- The design formula for TR-34's SFRC SOP is consisted based on the equivalent flexural tensile strength ratio ($R_{e,3}$).

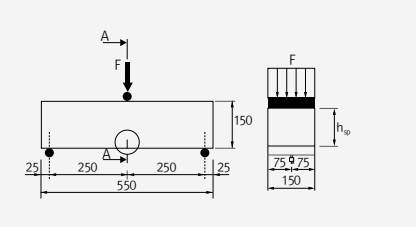


Figure 1

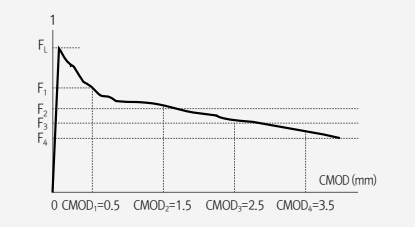


Figure 2

Test Result

Specimen Production

Under Loading Test

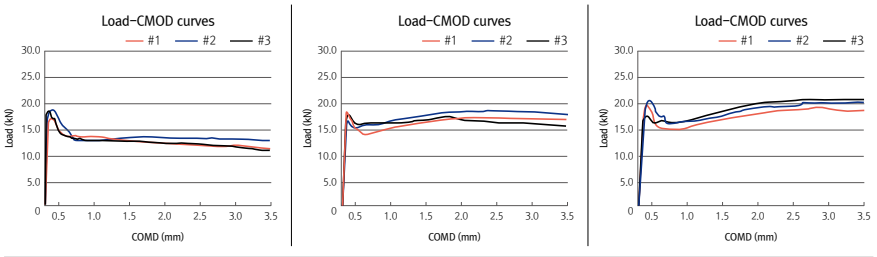
Complete Test

Residual flexural strength								
Steel Fiber (BUNDREX®)				Input (kg/m^3)	Test result (MPa)			
Spec.	Lenght (mm)	Diameter (mm)	Tensile strength (MPa)		F_{r1}	F_{r2}	F_{r3}	F_{r4}
KF 80/60	60	0.75	1,100	20~40	2.43~4.70	1.63~4.02	1.30~3.51	1.09~3.11
			1,400	20~40	4.01~4.73	3.91~5.41	3.78~5.75	3.52~5.70
KF 67/60	60	0.90	1,800	20~40	4.00~6.49	4.31~7.38	4.48~7.79	4.46~7.80

Load-displacement curve (KF 80/60 1,400MPa)

Input (kg/m^3)

20	30	40



'SFEED Pro' designs based on the performance test data (Re, 3) of KOSTEEL's BUNDREX. Therefore, projects designed by 'SFEED Pro' must use BUNDREX and not any other products.

Examples of Design Review

Construction Performance and Certification

Korea

- Mountain&Field Po-Chun Factory Construction
- City Airport, Logis & Travel, Incheon Airport Logistics Center Construction
- Samsung Pyeongtaek Factory Construction
- FILA KOREA Icheon Logistics Center Construction
- WACKER CHEMICAL KOREA Jin-Chun Factor Construction
- KT Logistics Center Construction
- KODACO Factory(7th) Construction
- LG ELECTRONICS Pyeongtaek DIGITAL PARK PRODUCT TECHOLOGY CENTER

Overseas

- Michelin Project (Thailand)
- Thai Bev Project Korat (Thailand)
- Amazon Factory Project (Thailand)
- Silver Oak Project (Thailand)
- Limingantulli Project (Finland)
- TA Asumisoikeus oy SOP Project (Finland)
- Lapuan Halpaphalli Project (Finland)
- Ita-Pori Liikuntakeskus SOP Project (Norway)
- Logistics Center (Finland)
- As.Oy Joensuun Viitta SOP Project (Norway)

Floor Slab Design Standard

SFRC SOP design is carried out in accordance with T-34, the British Floor Slab Design and Construction Guide.

SFRC flexural strength performance test and CE certification

BUNDREX has been tested for flexural strength in accordance with BS EN-14651 2005, Fiber reinforced concrete notched beam flexural strength performance test standard. KOSTEEL has CE certification.
1400~1,500MPa High tensile steel fiber CE certified products are widely used as a structural reinforcement for pile support floor slab concrete structures.

Do you still only use rebar as concrete reinforcement?

KOSTEEL's Globally Patented **BUNDREX®**

Reduce construction cost by **20**% and
Construction period by **40**%

NEW

Advantages of **BUNDREX®**

1. **Superior Cost Saving**
   Save 20% compared to reinforcing bars
2. **Superior Quality Improvement**
   Remarkable crack reduction and durability improvement of concrete
3. **Faster Construction Period**
   Reduce construction period by 40% by pouring directly from concrete mixer truck without reinforcement work
4. **Real-Time Structural Calculation**
   On-site customized solution

Patent No.: 10-1596246 (Korea) / US 10,414,691 B2 (USA)

More Pull – Out Energy

1. Enhanced total length of resistance (Lt) compared to existing shapes
2. Enhanced shape resistance compared to existing shapes

More SFRC Performance

Enhanced 10-20% SFRC performance, compared to previous SFRC

Product code	D(mm)	L(mm)	L/D
KF 65/35 CA	0.55	35	64
KF 80/60 CA	0.75	60	80

POHANG PLANT 2

Location : 549, Ho-Dong, Nam-Gu, Pohang, Gyeongsangbuk-Do
Products : Steel Fiber
Tel : +82. 54. 278. 0314 Fax: +82. 054. 278. 0307

SEOUL HEAD OFFICE

Haustory 4th Floor, 32-4, Junnong-Dong, DongDaeMun-Gu, Seoul, Korea
Tel : +82. 2. 2106. 0195
Fax: +82. 2. 2106. 0240

KOSTEEL EUMSEUNG PLANT 3

2-6, Soseok-Ri, Daeso-Myeon, Eumseung-Gun, Chungcheongbuk-Do
Products : Deck Plate
Tel : +82. 43. 882. 7893
Fax: +82. 43. 882. 7898

KOSTEEL POHANG PLANT 1

286, Ho-Dong, Nam-Gu, Pohang, Gyeongsangbuk-Do
Products : Wire Rod, Rebar, Steel Wire
Tel : +82. 54. 278. 0300
Fax: +82. 54. 278. 0307

KOSTEEL VINA PLANT IN VEITNAM

KOSTEEL VINA Nhon Trach II Industrial Zone, Dong Nai Province, Vietnam
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