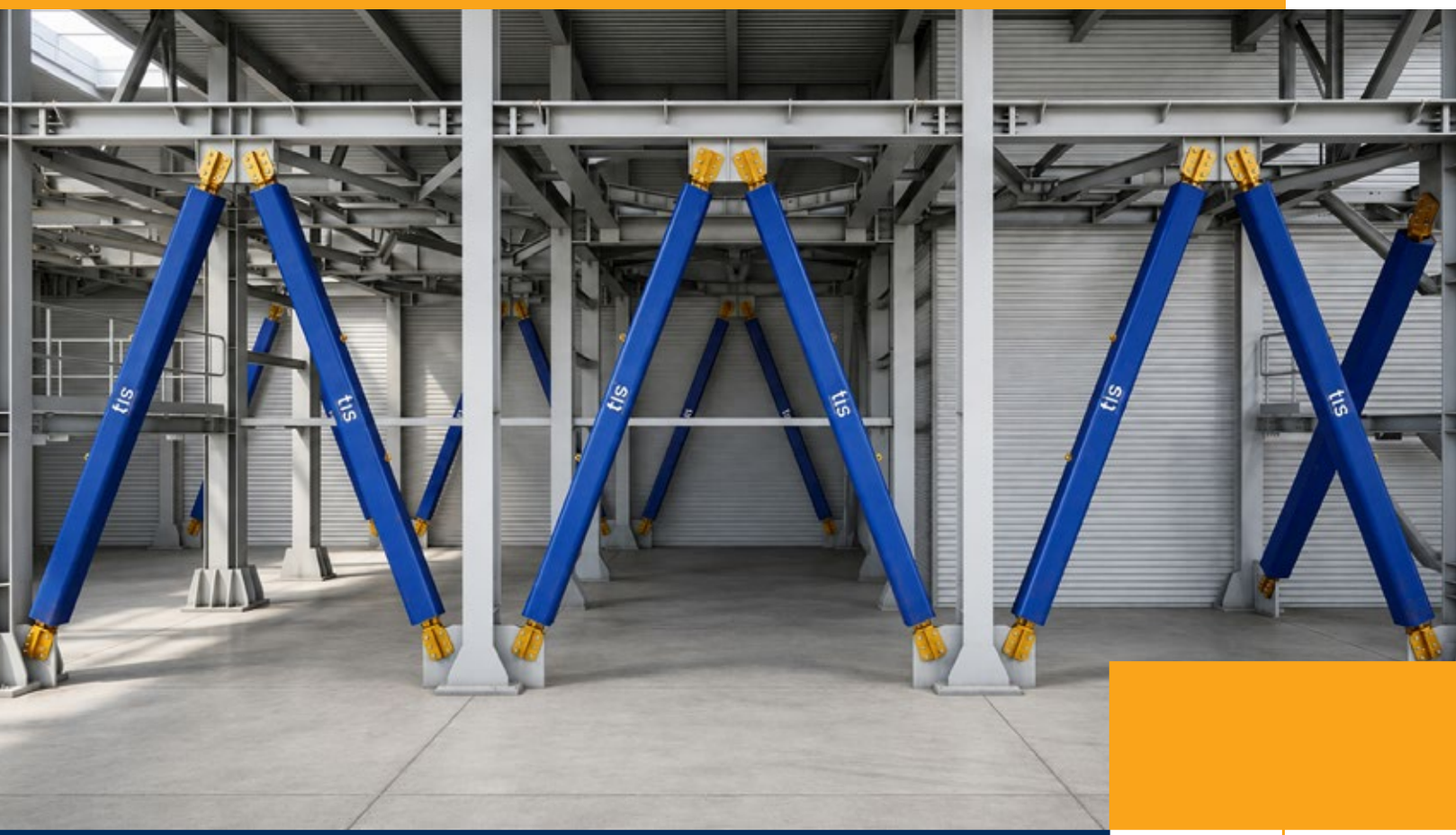
Next-Generation Seismic Engineering

# TIS Replaceable-Core Buckling-Restrained Brace: T-BRB




tis®
Earthquake Technologies

# TİS Ecosystem

## Engineering Excellence Growing Stronger Since 2014:

TİS Earthquake Technologies integrates engineering, manufacturing, and R&D processes within a comprehensive framework through the solutions it develops in the fields of seismic isolation and seismic control systems. Its engineering approach, continuously advanced since 2014, is supported by a robust manufacturing infrastructure and academic collaborations.

## Scale and Excellence in Manufacturing:

With 20,000 m² of indoor space and 200,000 m² of outdoor space, we have the highest manufacturing capacity in the region. As part of our academic collaborations, we validate our products together with prestigious institutions such as Middle East Technical University, Manisa Celal Bayar University, and Politecnico di Milano.

# Next-Generation Seismic Protection: T-BRB

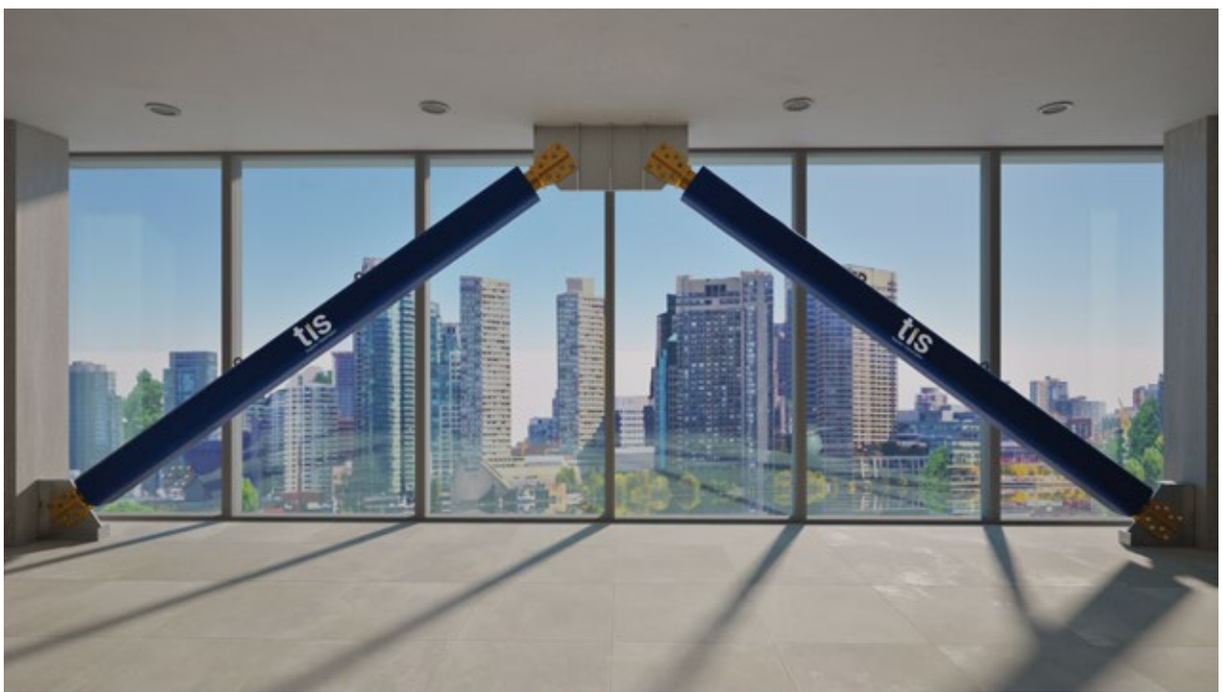
The primary objective of structural earthquake engineering is to design earthquake-resistant structures with sufficient strength, stiffness, and ductility under seismic loads. Developed in line with this objective, T-BRB is a modular buckling-restrained brace consisting entirely of steel components and featuring a replaceable core.

## Beyond Conventional Braces

These next-generation braces eliminate the buckling problem encountered in conventional concentrically braced frame systems and dissipate the seismic energy generated during earthquakes through stable plastic deformation.

## Engineering-Driven Reliability

Designed to maintain structural integrity even under the Maximum Considered Earthquake (MCE) ground motions, the T-BRB ensures the service life and safety of your structures with its proven high stiffness and high ductility capacities.



# Why T-BRB?

## Superior Quality Control and Material Reliability

### All-Steel Restraining Mechanism

Unlike conventional filled BRBs, T-BRB features a buckling-restraining mechanism made entirely of steel components, without the use of concrete or mortar.

**Measurable Performance:** By eliminating material uncertainty, the mechanical properties of every component can be verified on the production line.

**Industrial Consistency:** Manufactured in a controlled factory environment using high-precision welding and assembly details, it eliminates unexpected issues on site.

# Why T-BRB?

## Maximum Speed
## Minimum Waiting Time

### Rapid Manufacturing and Immediate Use

Time is one of the most critical cost factors in construction projects.

**No Curing Time Required:** Without having to wait for concrete or filling materials to gain strength, T-BRB is ready for installation immediately after manufacturing.

**Predictable Construction Schedule:** Its rapid manufacturing and installation cycle offers a unique advantage for urgent strengthening projects and demanding construction schedules.

# Why T-BRB?

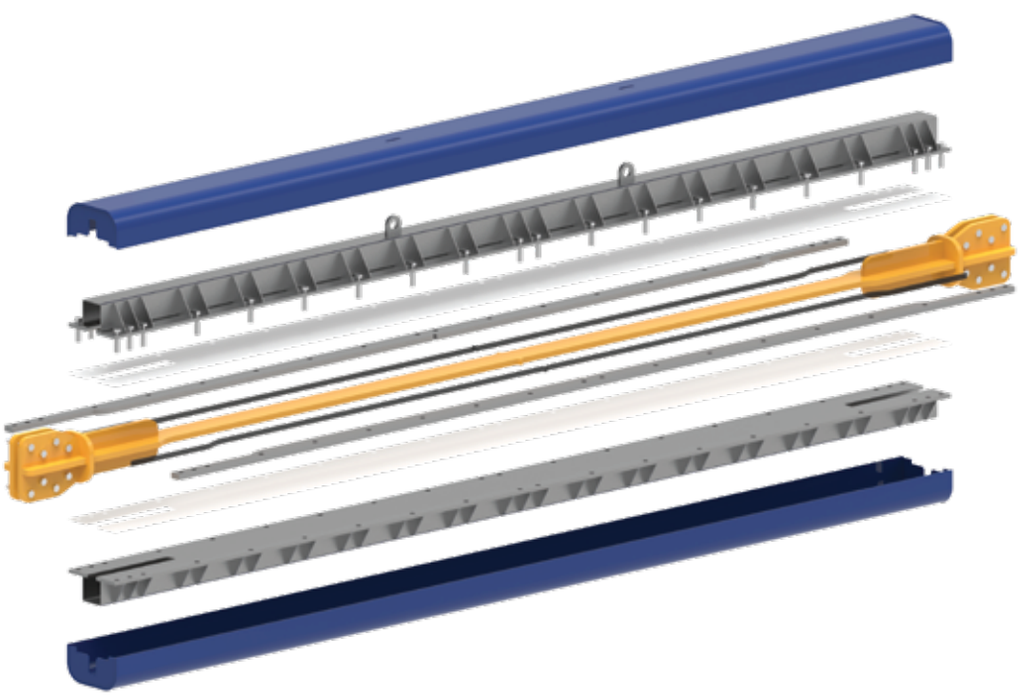
## Logistics and Installation Flexibility

### Modular and Portable Design

T-BRB offers ease of installation in confined spaces and challenging construction-site conditions.

**Smart Logistics:** Its modular components optimize transportation and storage processes.

**Easy Installation:** Its lightweight configuration and modular structure reduce the need for heavy-duty cranes, thereby lowering installation costs.



# Why T-BRB?

## Sustainable Safety and Cost-Effective Maintenance

### Replaceable Steel Core

An earthquake is not the end, but a manageable process.

**Cost Efficiency:** Following a severe earthquake, only the damaged core element can be easily replaced without damaging the restraining mechanism.

**Operational Continuity:** The system can be restored to its original seismic performance at a low cost without requiring comprehensive strengthening of the structure or complete replacement of the braces.

# Why T-BRB?

## High Seismic Performance

### High Plastic Deformation Capacity and Technoslide

**Stable Energy Dissipation:** It exhibits stable hysteretic behavior at strain levels of up to 4.0% without experiencing strength degradation under cyclic loading.

**Patented Isolation Technology:** The patented Technoslide isolation material reduces friction between the core and the buckling-restraining mechanism, ensuring consistent performance under long-cycle loading.

# Why T-BRB?

## Overall Project Economy

### Low Overstrength Factors

T-BRB is more than a brace; it is a design tool that makes the structure more economical by optimizing the entire lateral load-resisting system responsible for carrying seismic loads.

**Optimized Structural System:** Thanks to their low adjustment factors (β and ω), T-BRBs prevent unnecessary capacity increases and oversized sections in columns, beams, and connections

**Foundation Design Advantage:** Limiting the forces transferred from the superstructure to the foundation and making them predictable enables smaller foundation dimensions, resulting in significant savings in excavation and reinforced-concrete costs.

# Experimental Validation Through Full-Scale Testing

## Prototype Tests:

The adequate seismic performance of T-BRBs, as defined by the requirements of AISC 341, has been experimentally validated through full-scale prototype tests conducted at the Structural and Earthquake Engineering Laboratories of Manisa Celal Bayar University.

As a result of these tests, the following properties of T-BRBs were successfully observed:

- High energy-dissipation capacity,
- Stable hysteretic behavior,
- Sustained strength under cyclic loading.

## Academic Studies:

In experimental studies conducted in collaboration with the Department of Civil Engineering at Manisa Celal Bayar University (MCBU), the axial displacement capacities, β and ω adjustment factors, energy-dissipation capacities, and equivalent viscous damping ratios of T-BRBs were scientifically documented.

## Conference Papers:

The test results were presented at international platforms such as SDSR 2016 and 13NCEE and contributed to the body of literature on TİS engineering through conference papers.

## Engineering proven both in the field and in the laboratory.

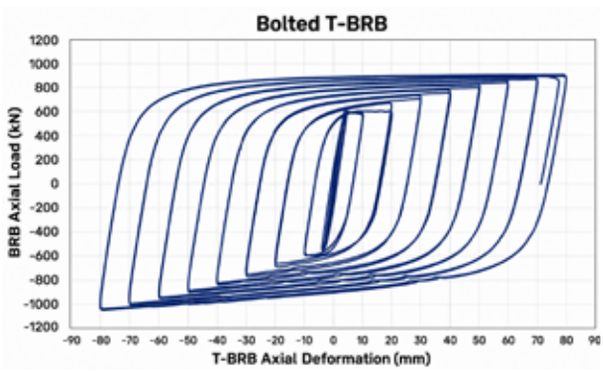


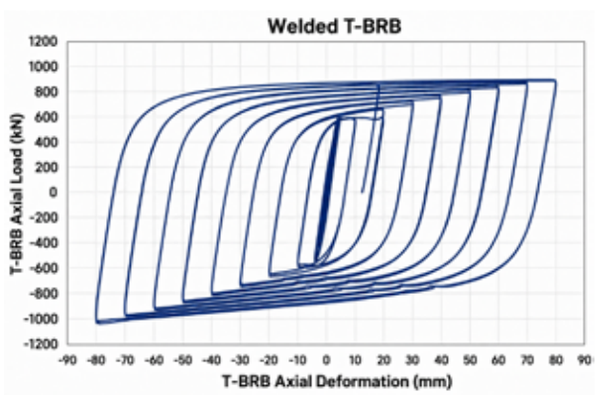
Bolted

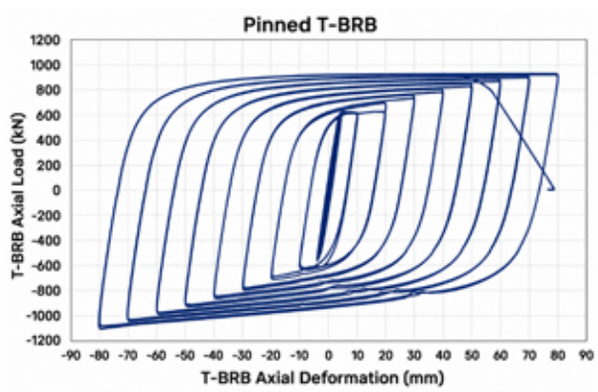
Welded

Pinned

# Hysteretic Behavior



# Design Adjustment Factors

The following factors used in the design of frames incorporating T-BRBs:

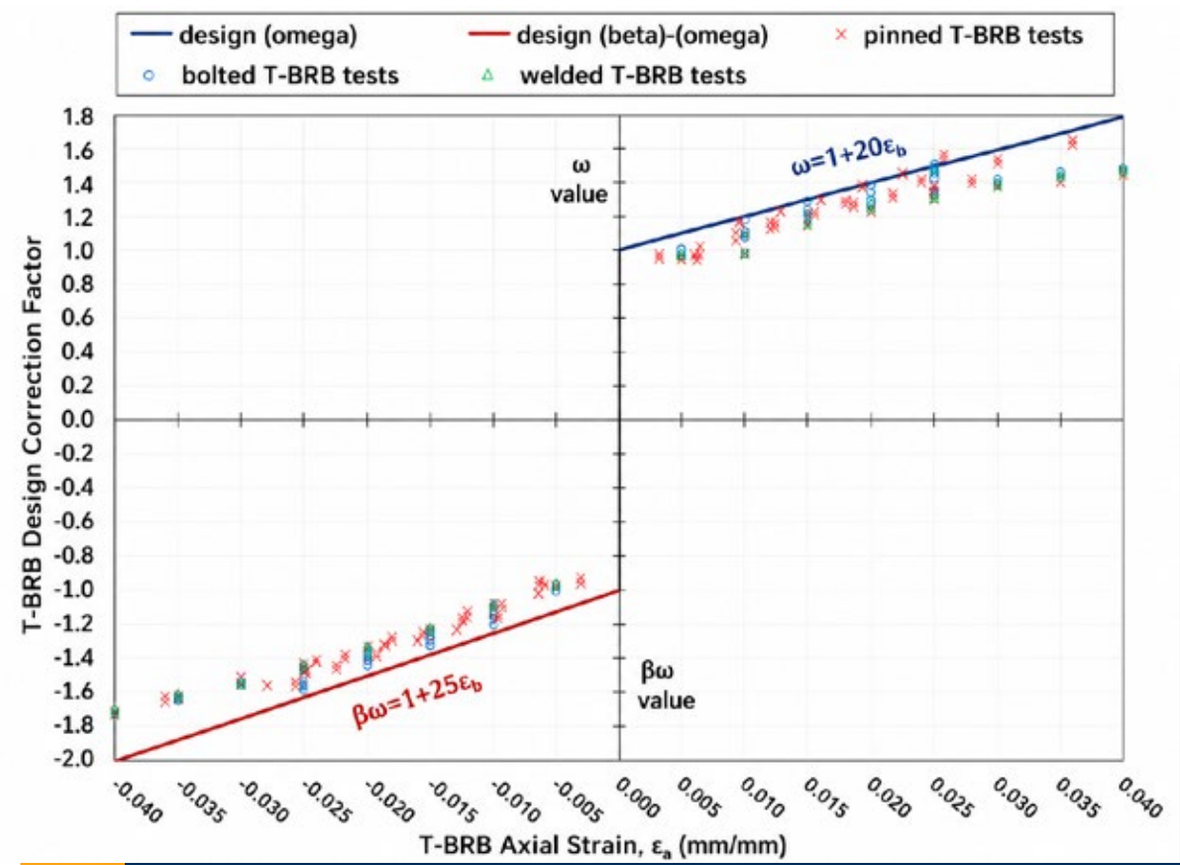
- ω (omega), the strain-hardening adjustment factor for the tension region
- βω (beta.omega), the compression times strain-hardening adjustment factor for the compression region

have been experimentally determined and provide reliable parameters for designers.

$\omega = 1+20\varepsilon_b$
$\beta\omega = 1+25\varepsilon_b$

Here, $\varepsilon_b$ represents the axial strain value of the T-BRB.

## T-BRB Design Adjustment Factors (ω and βω)



# T-BRB Full-Scale Test Results and Advanced Performance Analysis

**Technical Evaluation and Performance Data**

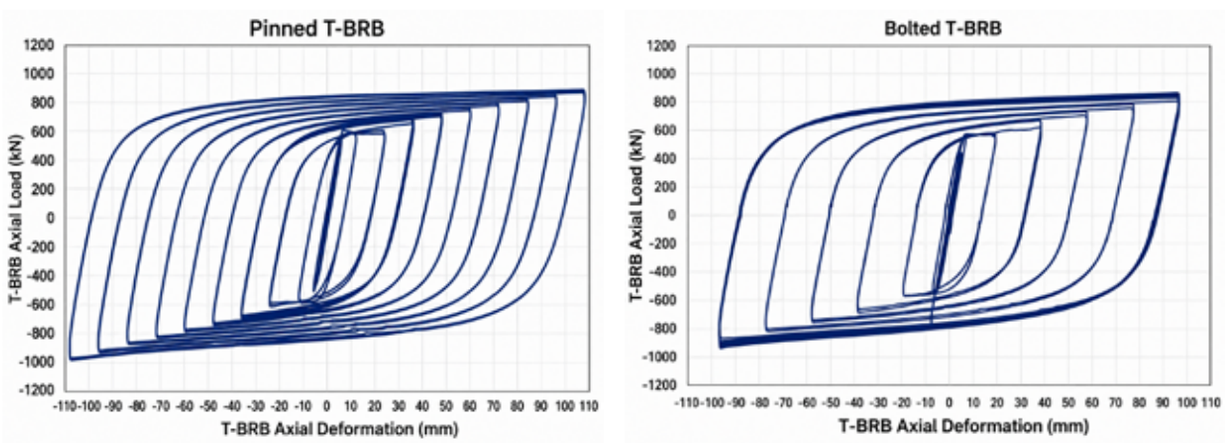
The T-BRB specimen, featuring a core cross-sectional area of 22.5 cm² and an approximate yield strength of 600 kN, fully exhibited the expected behavior by remaining entirely within the elastic range without any premature yielding up to the target yield displacement of 6 mm during the test.

**AISC 341-22 Loading Protocol Results:**

- Maximum β compression strength adjustment factor: 1.03
- Maximum ω strain-hardening adjustment factor: 1.16

These low factors indicate a level of superior performance rarely encountered in the BRB literature. This stability, achieved through the patented TechnoSlide debonding technology developed in collaboration between TİS and Politecnico di Milano, enables the additional loads acting on connection elements in new structures and anchors in existing structures to be reduced by approximately 50%.

**Advanced Performance and Hysteretic Behavior:**




Under the additional loading cycles applied after the AISC protocol, reaching displacement levels of up to $18\Delta_{by}$, the T-BRB specimen maintained its stable behavior. As clearly demonstrated by the presented hysteretic curve, the brace continued to dissipate a substantial amount of energy with excellent symmetry and without any loss of strength or stiffness:

- Cumulative inelastic deformation: $1396\Delta_{by}$
- Energy dissipated: ~6 MJ
- Average equivalent viscous damping ratio: 46%

**Innovative and Sustainable Approach:**

With its replaceable core configuration, the renewable T-BRB introduces a new approach to earthquake engineering in terms of both high performance and economical design.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# T-BRB Product Catalogue Table

TİS

T-BRB - 20

Core Plate
Cross-Sectional Area, cm²

| T-BRB Product Code | T-BRB Yield Strength | | | | Core Plate Geometry | | | Ultimate Internal Forces | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Assumed for the Link Model | Nominal | Design | Expected | Thickness | Width | Area | 2% Strain | | 4% Strain | |
| | | | | | | | | Tension | Compression | Tension | Compression |
| | $F_y$=300 MPa | $F_y$=275 MPa | | | | | | ω=1.4 | βω=1.5 | ω=1.8 | βω=2.0 |
| | $P_y$ | $P_{ysc}$ | $\Phi P_{ysc}$ | $R_y \cdot P_{ysc}$ | t | w | $A_{sc}$ | $T_{max}$ | $P_{max}$ | $T_{max}$ | $P_{max}$ |
| | (kN) | (kN) | (kN) | (kN) | (mm) | (mm) | ($mm^2$) | (kN) | (kN) | (kN) | (kN) |
| T-BRB-1 | 30 | 28 | 25 | 33 | 5 | 20 | 100 | 42 | 45 | 54 | 60 |
| T-BRB-2 | 60 | 55 | 50 | 66 | 5 | 40 | 200 | 84 | 90 | 108 | 120 |
| T-BRB-3 | 90 | 83 | 74 | 99 | 6 | 50 | 300 | 126 | 135 | 162 | 180 |
| T-BRB-4 | 120 | 110 | 99 | 132 | 8 | 50 | 400 | 168 | 180 | 216 | 240 |
| T-BRB-5 | 150 | 138 | 124 | 165 | 10 | 50 | 500 | 210 | 225 | 270 | 300 |
| T-BRB-6 | 180 | 165 | 149 | 198 | 12 | 50 | 600 | 252 | 270 | 324 | 360 |
| T-BRB-8 | 240 | 220 | 198 | 264 | 12 | 67 | 800 | 336 | 360 | 432 | 480 |
| T-BRB-10 | 300 | 275 | 248 | 330 | 15 | 67 | 1000 | 420 | 450 | 540 | 600 |
| T-BRB-12 | 360 | 330 | 297 | 396 | 15 | 80 | 1200 | 504 | 540 | 648 | 720 |
| T-BRB-15 | 450 | 413 | 371 | 495 | 20 | 75 | 1500 | 630 | 675 | 810 | 900 |
| T-BRB-20 | 600 | 550 | 495 | 660 | 20 | 100 | 2000 | 840 | 900 | 1080 | 1200 |
| T-BRB-25 | 750 | 688 | 619 | 825 | 25 | 100 | 2500 | 1050 | 1125 | 1350 | 1500 |
| T-BRB-30 | 900 | 825 | 743 | 990 | 25 | 120 | 3000 | 1260 | 1350 | 1620 | 1800 |
| T-BRB-35 | 1050 | 963 | 866 | 1155 | 25 | 140 | 3500 | 1470 | 1575 | 1890 | 2100 |
| T-BRB-40 | 1200 | 1100 | 990 | 1320 | 25 | 160 | 4000 | 1680 | 1800 | 2160 | 2400 |
| T-BRB-45 | 1350 | 1238 | 1114 | 1485 | 30 | 150 | 4500 | 1890 | 2025 | 2430 | 2700 |
| T-BRB-50 | 1500 | 1375 | 1238 | 1650 | 25 | 200 | 5000 | 2100 | 2250 | 2700 | 3000 |
| T-BRB-60 | 1800 | 1650 | 1485 | 1980 | 30 | 200 | 6000 | 2520 | 2700 | 3240 | 3600 |
| T-BRB-70 | 2100 | 1925 | 1733 | 2310 | 35 | 200 | 7000 | 2940 | 3150 | 3780 | 4200 |
| T-BRB-80 | 2400 | 2200 | 1980 | 2640 | 40 | 200 | 8000 | 3360 | 3600 | 4320 | 4800 |
| T-BRB-90 | 2700 | 2475 | 2228 | 2970 | 40 | 225 | 9000 | 3780 | 4050 | 4860 | 5400 |
| T-BRB-100 | 3000 | 2750 | 2475 | 3300 | 40 | 250 | 10000 | 4200 | 4500 | 5400 | 6000 |
| T-BRB-SPC | Custom-designed T-BRBs can be manufactured in intermediate sizes to meet project-specific requirements. | | | | | | | | | | |

# Reference Projects Domestic

Türkiye - Hatay
Industrial Facility
Reinforced-Concrete Retrofitting Project

# Reference Projects International

Peru - Lima
Hospital Building
New Reinforced-Concrete Building

# Our Quality, Environmental, and Occupational Health and Safety Policy

At TİS, by adopting a sustainable management approach in the fields of quality, environment, and occupational health and safety, we undertake to:

Continuously improve our management system by ensuring full compliance with the ISO 9001 Quality, ISO 14001 Environmental, and ISO 45001 Occupational Health and Safety Management System standards;

Prioritize customer satisfaction by manufacturing products that comply with quality, environmental, and safety standards and delivering them on time;

Maintain our leadership in the industry by improving our manufacturing and project-management processes while optimizing costs;

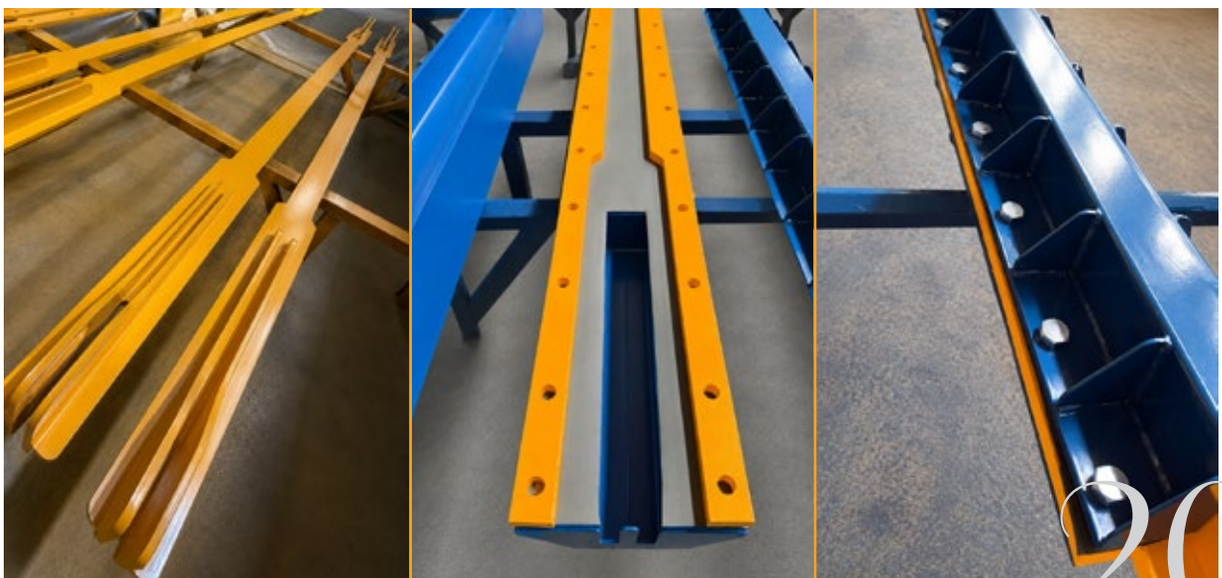
Invest in the training of all our employees, enhance their competencies, encourage active participation in training programs, and provide advanced engineering solutions;

Improve our manufacturing processes to minimize waste and reduce energy consumption by limiting the use of natural resources with a strong commitment to environmental protection;

Prioritize occupational health and safety by identifying and minimizing risks with the participation of our employees, stakeholders, and employee representatives, and prevent occupational diseases and workplace accidents;

Conduct our activities in full compliance with international standards and legal requirements;

Protect the information security and personal data of our customers, suppliers, stakeholders, and employees, respond to potential breaches as quickly as possible, and ensure uninterrupted business continuity.



# Certificates

TİS products are certified in accordance with international quality, safety, and engineering standards. Manufacturing, quality-management, and product-performance processes are audited according to international standards and certified by independent organizations. These certificates demonstrate that TİS solutions are designed, manufactured, and tested in compliance with European and international engineering standards.

## TİS holds the following principal certificates:

- CE Certificate of Constancy of Performance
- ISO 9001 – Quality Management System
- ISO 14001 – Environmental Management System
- ISO 45001 – Occupational Health and Safety Management System
- ETA – European Technical Approval
- Certificate of Constancy of Performance (Structural Bearings)
- Fire Resistance Test Certificate (Efectis)

TÜVNORD

Dedal Attestation & Certification

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Efectis

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# Integrated Earthquake Technologies

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