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Calibration Service as a Gateway to Sustainable Research and Development

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Summary:

Over decades, the German Federal Institute for Materials Research and Testing (BAM) has established a sophisticated calibration laboratory for force, temperature and electrical quantities. Since more than 15 years it is accredited, currently by the national accreditation body (DAkkS), and offers its service also to external entities on a global scale. As a public provider, we are furthermore committed to research and development activities that demand measurements with highest quality and low level of uncertainties. Two R&D examples are highlighted within this contribution.

Keywords: calibration of force, calibration of temperature, calibration of electrical quantities, measurement uncertainty, new sensor principles

Measurement and Calibration Capabilities

Calibration and testing are key elements in the field of activities of the Federal Institute for Materials Research and Testing (BAM), which is dedicated to safety in technology and chemistry. In order to ensure the reliable metrological traceability of its measuring equipment, BAM maintains its own calibration laboratory and optimized it over many years to achieve excellent conditions for highly precise measurements.

This particularly includes highly stable environmental conditions with minimum impact of perturbating thermal, mechanical, radiative or acoustic factors as well as a comprehensive inventory of high-end measuring equipment and calibration standards and facilities. Most of the reference standards in operation are directly linked to national standards, allowing small measurement uncertainties to be provided. Furthermore, we can rely on a profound expertise acquired over many years of dedicated operation. The BAM calibration lab is accredited to comply with the respective requirements of ISO/IEC 17025 since 2009 (ID: D-K-11075-08-00), confirming the effectiveness of its up-to-date quality management system and its competence in calibration. An extract from the scope of accredited calibrations, including its associated minimum measurement uncertainties, can be found in Table 1.

Tab. 1. Extract of the scope of accredited calibrations. Given are the best measurement capabilities (k = 2), the full scope can be found in [1].

Quantity	Range	Capability [1]
Force		
Tensile and compressive	10 N to 2 kN	0.01%
	0.4 kN to 5 MN	0.02%
Compressive	4 MN to 21 MN	0.1%
Temperature		
PRTs (*e.g.* Pt100)	-50°C to 160°C	0.03 K
Non noble TCs	-50°C to 160°C	0.25 K
Noble TCs	0°C to 160°C	0.5 K
Electrical		
DC current	>100 nA to 20 A	>1 nA
DC voltage	0 µV to 1000 V	>1 µV
DC resistance	100 µΩ to 1 GΩ	>4 ppm
Charge	5 pC to 100 nC	>0.1%
Voltage ratio	±[2 to 50] mV/V	>0.03 µV/V

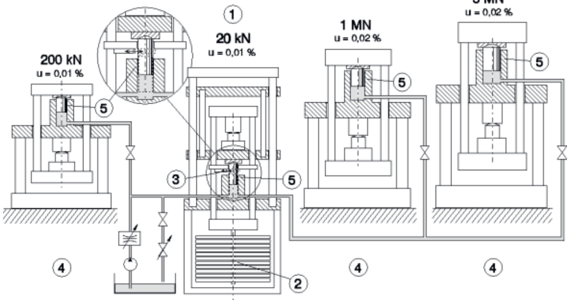

Fig. 1. Dead-weight force reference standard facility at BAM: (1) Dead-weight equipment and managing system, (2) Dead-weight stack up to 20 kN, (3) Hydraulic abutment, (4) Hydraulic connection, (5) Rotating pistons.

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One of the core facilities at the BAM calibration lab is the hydraulically transmitted dead-weight force reference standard that provides a cascaded application of defined load up to 5 MN, as schematically depicted in Fig. 1.

Hydraulically Balanced Build-Up System for Load Measurements up to 25 MN

In order to satisfy the increasing demand for large force measurements, several high-load force transducers can be assembled in parallel to form a build-up system (BUS) [2]. In this way, five off-the-shelf 5 MN load cells can measure a compressive force of up to 25 MN. As such a system can also be operated with a lower number of cells, it represents a cost effective and versatile tool for a large range of precise high-load measurements, compared to a single custom-designed transducer for larger forces.

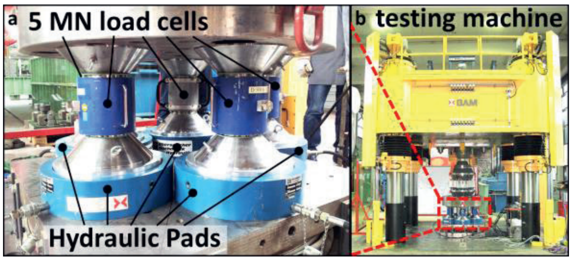

Fig. 2. 5x5 MN build-up system with hydraulic balancing (a), installed into the 25 MN testing machine at BAM (b).

BAM developed a coupled hydraulic balancing system for such BUS, as shown in Fig. 2a, which allows a homogeneous force distribution into the individual load cells, to achieve maximum load capacity also under unfavorable conditions. In addition, it allows generating defined off-axis loads on demand, without any retooling. Thorough traceable calibration of the single 5 MN load cells is necessary to achieve an expanded measurement uncertainty of down to 0.1% for the 25 MN BUS. Furthermore, the BAM calibration lab conducted comparative measurements of the entire system with static BUS: 3x7 MN from the Swiss Federal Laboratories for Materials Science and Technology (EMPA) [3] and 3x10 MN from the German National Metrology Institute (PTB), as depicted in Fig. 2b. As a result, the scope of our accredited calibrations for compressive force was extended to 21 MN.

In-situ Measurements of the Tension Robe Stress in Pretensioned Concrete

The life cycle of pretensioned concrete based infrastructure, particularly bridges, significantly depends on the condition of its tension robes. The impact of aging on the resilience of the buried metal tension robes is not fully understood, yet.

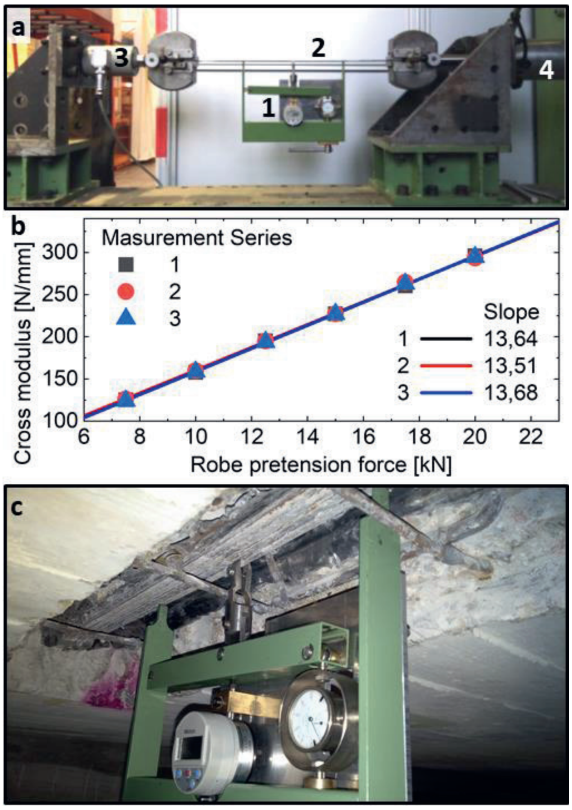

Fig. 3. Tension robe measuring bracket. a) mounted in the calibration setup with 1: the bracket, 2: pretension string, 3: tensile force transducer, 4: tensioner. b) response curve, c) mounted on Leinebridge for in-situ measurements.

BAM developed a specific measuring bracket to determine the prestress of a single partially excavated tensioning string via a perpendicular stress-strain test. [4] Comprehensive calibrations of the novel device in dependence of well-defined pretensions on a withdrawn real-aged string specimen were performed (Fig. 3a) in order to generate the characteristic response curve presented in Fig. 3b. By using the calibration parameters thus derived, measurements of individual tensioning robes were performed *in-situ* on an operating bridge, in a minimal invasive fashion, as shown in Fig. 3c.

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