Capacity Building and Skills Development Programme for the Laboratories of the Local Government Infrastructure and Transportation Research Centre (LoGITReC) in Tanzania

Final Equipment Status Report

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Cover photo: President's Office, Regional Administration and Local Government in Dodoma, Tanzania

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Abstract

This project is aimed at assisting the Local Government Infrastructure and Transportation Research Centre (LoGITReC) in Tanzania, but specifically the Local Government Infrastructure and Transportation Research Centre Materials Laboratory (CMRL) in Dodoma, hereinafter referred to as CMRL, to achieve its objective of capacity building and skills development for its staff. This will enable the facility to operate as a reference and quality control laboratory for PO-RALG and to support research activities by LoGITReC. The project was designed and planned to be implemented through three main capacity building activities, namely: (i) capacitation of laboratory staff, through hands-on training of the technicians in laboratory testing according to the CML Laboratory Testing Manual (2000) of Tanzania and secondment of the Laboratory Manager to an ISO 17025 accredited research laboratory, (ii) development of operational systems for the laboratory and (iii) procurement of additional equipment. The overall purpose of this project is to equip CMRL with the necessary skills and additional equipment.

This report focuses on Task 3 of the project, covering aspects related to status of existing equipment and the procurement of additional equipment. New and additional equipment will enable CMRL to be fully functional and be able to satisfy the basic requirements of PO-RALG and LoGITReC, in terms of road materials testing.

A priority list for additional equipment was developed with the assistance of the project team and submitted by CMRL for procurement. The list of additional equipment required for CMRL to undertake the testing of aggregates, concrete, unbound materials and stabilised materials is provided in this report. Guidance is also provided to implement proper calibration, verification and checks to ensure functionality of equipment.

Task 3, required that an assessment of all available equipment, including that procured with AfCAP support, be conducted to ensure it is properly installed and calibrated. At the time of writing this report, the new equipment had just been received, and the project team is to assist in the installation and ensure it is properly calibrated. The assessment in this report is therefore limited to existing equipment.

Key words

Capacity building, research skills development, equipment calibration, equipment verification and equipment maintenance.

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Acronyms

AfCAP	:	Africa Community Access Partnership
CMRL	:	Central Materials Research Laboratory
CSIR	:	Council for Scientific and Industrial Research
ISO	:	International Organisation for Standardisation
LoGITReC	:	Local Government Infrastructure and Transportation Research Centre
PO-RALG	:	President's Office, Regional Administration and Local Government
TANROADS	:	Tanzania National Roads Agency
TBS	:	Tanzania Bureau of Standards

Contents

1 Introduction

The availability of appropriate equipment is essential for a materials testing laboratory to be fully functional as a reference and research laboratory. As part of the capacity building and skills development project for Tanzania, Africa Community Access Programme (AFCAP) has provided funding for the acquisition of basic equipment for CMRL. The initial list of the equipment acquired through AFCAP is provided in the Capacity Building and Skills Development Plan[1].

The Capacity Building and Skills Development Plan also provided a list of equipment that PMO-RALG was to purchase as well as equipment considered critical to the future operations of CMRL. On the basis of the Capacity Building and Skills Development Plan, Task 3 of the current project focuses on procurement of additional equipment, including the assessment of the calibration status and serviceability of the existing equipment, and assisting the CMRL personnel to ensure all equipment is calibrated and serviceable.

This report covers and highlights the activities that were undertaken in support of achieving the objective of Task 3, focusing on the status of existing equipment only. Assistance is to be provided to CMRL to ensure that the newly received additional equipment will be properly installed and calibrated and this will be reported in the Final Report.

[1] Verhaeghe, BMJA. Technical Assistance to Tanzania Local Government Infrastructure and Transportation Research Centre (Interim Phase) Capacity Building and Skills Development Action Plan. AFCAP CONTRACT REF NO. AFCAP/TAN/2046A. December 2015.

2 LoGITReC-CMRL Equipment Status

2.1 Existing equipment

Appropriate and adequate equipment should be in place for a laboratory such as CMRL to function efficiently and effectively as a reference and research laboratory. The equipment should support the core operations of the laboratory to provide the required service efficiently and reliably.

The full list of existing equipment showed that the current available equipment was inadequate for CMRL to conduct the priority tests as identified in the Capacity Building and Skills Development Plan. As a priority, these include tests on unbound, modified, stabilised and concrete materials in line with the Laboratory Testing Manual published by the Ministry of Works in 2000. The inadequacy of the current equipment is more evident when one compares with the available equipment at TANROADS-CML in Dar es Salaam.

2.2 Required additional equipment

The need to acquire additional equipment was identified in the Capacity Building and Skills Development Plan and PO-RALG was to purchase the additional equipment that could not be funded by AfCAP.

Discussions during the course of the project were held between LoGITReC team and project team on establishing a revised priority equipment list. A priority list was first drawn by the project Laboratory Management Specialist in December 2016.

Following CMRL Manager's secondment at the CSIR and during the hands-on training session in Dodoma, conducted in April 2017, further discussions were held between CMRL Manager and the project Laboratory Management Specialist. An assessment of equipment requirements for CMRL was again conducted and considering the immediate and medium- to long-term testing requirements, the two agreed on a new list. Table 1 shows the additional equipment requirements status in April and progress made as at September 2017.

Table 1: Additional required equipment status (April 2017 and September 2017)

Equipment	April 2017	September 2017
Personal protective equipment (long overdue).	**Very urgent** Laboratory staff being provided limited safety	**Not acquired (urgently needed)**
First Aid Kit; Fire extinguishers	**Urgent,** safety requirement	**Not acquired (urgently needed)**
Rifflers, with openings of 37.5, 25 and 10 mm. This is necessary for sample preparation and obtaining representative samples for testing	**Urgent**	Acquired = 2No. 1 - 45mm and 1 - 30mm slot width
Scale of approximately 25 kg capacity (15kg may also be used, but the higher capacity is preferable), readable to 1 gram	**Urgent**	Acquired a Dual range 60/150kg cap. X 2/5 g resolution, digital balance**.** *The 25kg scale readable to 1g is still urgently needed*

Scale of approximately 1000 g capacity, readable to 0.01g for determining weight of Atterberg Limits moisture content tins.	**Urgent** Current scale not sensitive enough	**Not acquired (urgently needed)**
Moisture content tins; 1kg – compactions, 50g – Atterberg Limits	Important	Acquired Moisture Content tins 18g = 16No, and 24g = 24No.
BS Linear shrinkage troughs – part of plasticity determination	**Urgent**	Acquired = 10No.
Concrete cube press	**Urgent** Should also be used for ACV, Ten percent fines, ACV and UCS	**Acquired**
Moulds for UCS (at least 4)	Urgent	**Not acquired (urgently needed)**
Hydrometer (at least 4)	--	**Not acquired** (urgently needed)
Auto compactor for granular materials	Urgent	**Not acquired (urgently needed)**
Apparatus to determine ARD/BRD and water absorption	Necessary	**Not acquired**
Durability Mill Index apparatus	Necessary	**Not acquired**
Vacuum pump – density determinations	Necessary	Acquired 1No
Triaxial testing equipment	Necessary	Acquired not installed, due to inadequate space
Large tarpaulin for drying samples	Necessary	**Not acquired**
Toolkit: screwdrivers, pliers, spanners	Necessary	**Not acquired**
Measuring tapes/rulers (5m min), long steel rule (1m), chisels and hammers, 3m straight edge	Necessary	Currently acquired; 30m long fibreglass tapes = 2No, 2m long steel tape = 2No, 2m long straight edge = 2No, metric graduated wedges = 4No
Additional medium sized oven	Necessary	Acquired

There is a concern that the acquisition of critical personal protective equipment is still pending and there is a need to address constraints in the procurement processes, as this is more likely to affect the efficiency of operating the laboratory in future.

2.3 Equipment serviceability

The importance of proper management of laboratory equipment, inclusive of maintenance and calibration requirements was covered during the hands-on training. It should also be noted that this is a requirement for a facility that must comply with ISO 17025[2]. The project Laboratory Management Specialist demonstrated to the laboratory personnel on how they should become accustomed to the management of laboratory equipment.

[2] ISO/IEC 17025:2005. General requirements for the competence of testing and calibration laboratories

2.3.1 Verification of existing equipment

While demonstrating on how to conduct equipment check, it was found that the scale being used to weigh samples was out of calibration giving a reading of 997 grams when a calibrated weight of 1000 grams was placed on it. On checking the calibration sticker it revealed that the last calibration should have taken place in 2016, but had not been done. This provided the best learning example on the importance of proper management of equipment, inclusive of their maintenance and calibration schedule. The lack of operational procedures may have contributed to the oversight to check when the equipment was due for calibration.

The second example was the penetration assembly weight (cone and stem) which was found to be 229 grams whereas it is supposed to be 80 grams. The implication is that it will lead to lower than normal Liquid Limit determinations.

The status of the existing equipment in the Laboratory is given in Table 2.

Table 2: Verification of existing equipment

Equipment	Condition	Action Taken/Recommendations made
Atterberg Limits		
LL penetrometer	Assembly overweight by 150g	Removed weights to required 80g
	Good - new	None
Cone condition	Good	None
Shrinkage troughs	Good - new	Buy BS troughs currently using ASTM type
Palette knives	Good - new	None
Moisture tins	Good	Too few in quantity, more needed
Balance-large platform	Not suitable for the test	Buy smaller scale (2000g, small platform)
Compaction		
Old hammer	Poor – underweight by approx. 180 g. Due to wear. Face of hammer rounded.	Stop using hammer
New hammers	Good – complying to specs	Use new hammer from then on.
Moulds	Good – new, comply to specs	Do not use old moulds
Trimming device	OK – straight, minimal wear	None
Gauge for swell	Good - new	Do not use old ones lying around
CBR		

Press general	Good - new	None
Load speed	OK	None
Load reading	OK	Checked by TBS 18 September 2017
Plunger Face	Good	None
Perforated base plates	Blocked	Unblock and clean regularly
Sieving		
Sieves condition	Good - new sieves	None
Sieve 0,075mm	Almost totally blocked	Sieve cleaned. New one used
Scale (6000g)	Calibration out (6g in 2000)	Must be calibrated
Impact Value		
Aggregate Impact Value Apparatus	Good - new	None
In situ density		
Sand replacement app.	Good - new	None
In situ strength		
Dynamic Cone Pen (DCP)	Good - new	None
Oven		
Door seals	New	None
Temp	Could not verify	Need thermometers. TBS verified OK
General operation	Good condition - new	None
Sample heating		
Hotplates	Good condition - new	None
Aggregate shape factors		
Flakiness gauge	Good – new, slots correct size	Slots correct size
Elongation gauge	Good - new	Distance between posts - correct

2.3.2 Verification and installation of newly acquired equipment

The newly acquired items comprised small laboratory items, a new cube press and the tri-axial apparatus. The small items required no installation or training for their use. On the other hand, the triaxial apparatus compared to the cube press require special installation procedures.

2.3.2.1 Installation of Triaxial Apparatus

The triaxial apparatus is a complex system and requires that the supplier or their agents assemble and commission to ensure full functionality of the whole system. Arrangements have been made with Controls who supplied the equipment regarding installation of tri-axial equipment. As suppliers they have the responsibility to test the individual components of the equipment to ensure functionality after the apparatus has been fixed in place. On advice by Controls, a visit was made to GST Lab in Dodoma by CMRL Manager, where similar equipment was supplied and installed by Controls. It was during this visit that it was noted that sufficient and uninterrupted space is required to install the equipment, space that is currently not available without making changes to the current laboratory arrangements. Approval is pending for Controls to come and assess the space proposed for locating the triaxial machine and to commission it.

2.3.2.2 Installation of Cube Press

Cube press – general description

The cube press is a complete stand-alone piece of equipment. This is an automatic cube press supplied by Controls and has a load capacity of 2000 kN (Figure 1). It can be used to crush concrete cubes, paving blocks, ACV, 10% FACT and UCS tests (Figure 1). The loading rate for testing can be manually set to perform tests according to specifications. The set loading rate is computer controlled and during the crushing tests, the machine stops the loading once failure of the specimen occurs. The maximum load attained and the calculated stress values are displayed on a screen.

For ACV and 10% FACT the press has to be manually stopped once the required load is attained (e.g. 400kN for ACV test) as there is no specimen failure for these tests. Otherwise the machine will simply continue loading until it reaches its maximum capacity. The operator therefore has to attentively observe the load readings on the screen provided so as to stop the loading at the correct point.

Training

The training using the Cube press involved the following tests:

- Cube crushing
- Block crushing
- Determination of unconfined compressive strength (UCS)
- ACV and 10% FACT (10% FCV).

(a) Cube crushing

The testing was carried out in accordance with CML Test 2.13. The test requires a loading rate of 12 – 24 MPa/min. A loading rate of 24 MPa/min was selected. The press can only be set in MPa/sec. It was thus set at 0.4 MPa/sec (24 MPa/60 secs).

Parameters, such as cube dimensions and weight are entered on the computer touch screen. The test was performed satisfactorily and the press stopped load application once the cube broke. The crushing force in kN and the cube strength in MPa were displayed on screen as expected

Figure 1: Newly acquired automated press

(b) Block crushing

Since there is no CML method for block crushing, as such the procedure followed was similar to that used for cube crushing. The same observations were made and no machine problems were experienced.

(c) UCS

The testing was done according to CML Test Method 1.21 which requires that a crushing rate of 140 kPa/sec be applied. The press was set to run at a rate of 0.14 MPa/sec and the test accordingly performed. No machine problems were experienced.

(d) ACV and TFV

There were no pre-set functions on the machine to do these tests and various loading rates had to be calculated according to the test method requirements. The technicians were trained on calculating these values and adjusting the load rates accordingly.

- The determination of the Aggregate Crushing Value was done in accordance with CML Test Method 2.6. The loading required was 400 kN applied uniformly over 10 minutes, which equates to 667 N/sec, which was the setting required as input for the press.

- 10% Fines Value determination was carried out according to CML Test Method 2.7. The test resembles the determination of the ACV.

A reference table for setting the machine for the different tests has been provided to CMRL and is presented in Appendix A.

2.4 Equipment calibration or verification

During the April 2017 visit, most of the equipment had Tanzanian Bureau of Standards (TBS) calibration stickers which indicated that re-calibration should have taken place some six months earlier (October 2016). This was brought to the attention of the Laboratory Manager for immediate action. As a guide, recommendations are given in Table 3 for the verification and/or calibration of equipment typically used in road materials testing laboratories. Guidance for Calibration, Verification and intermediate checks has also been provided as Procedure LoGITReC-LAB-2 in the complementary Report on Laboratory Operational Systems.

Table 3: Equipment Checking/Calibration Frequency

EQUIPMENT	Check/Calibration Frequency	
	Check	Calibrate
Balances, Scales and weights	Weekly	24 months
Test thermometers	When used	24 months
Analytical balances	When used	24 months
Weights		36 months
Timers		24 months
Ovens	When used	24 months
Penetrometer: Dial, timer		12 months
Penetrometer cones	When used	
Moisture tins	When used	
Compression or loading devices	3 months	24 months
Mechanical compactor	weekly	
Moulds		12 months
Manual hammer	weekly	
CBR Penetration Apparatus		12 months
Sieves	When used	
L. A. machine / Texas ball mill		24 months
Steel balls (L.A. apparatus)		24 months
Aggregate Impact Value apparatus	When used	12 months
Sand replacement apparatus	When used	12 months
Vacuum systems		24 months
Atterberg Limit device	When used	6 months

EQUIPMENT	Check/Calibration Frequency	
	Check	Calibrate
Flakiness/Elongation gauges		6 months
pH meter		12 months
pH probes	When used	
Water/oil baths	When used	12 months
Penetrometer needles	When used	
Ring and ball device		12 months
Brookfield viscometer		24 months
Viscometers (other)		36 months
Ductility apparatus		24 months
TFO & RTFO oven shelf/carriage		24 months
Load cells		24 months
Tri-axial apparatus	When used	24 months

3 Laboratory working space

Proper accommodation and working environment in a laboratory, includes monitoring of controlled areas, such as location and size of concrete water bath, effective segregation of tests, adequate storage areas, in accordance to the requirements of ISO 17025. Adequate and environmentally friendly working space for personnel to carry out the testing and equipment location is therefore essential. The project team made some observations in relation to the working space in and around the laboratory, during their visits to the laboratory. These are highlighted below with suggested recommendations:

- There is an undercover sample storage area not currently being used for samples. At the time of the last visit in April 2017, there were several 200l emulsion drums, motorcycles, bicycles, planks and it was also being used as a resting area for staff from the surrounding offices. The area is supposed to be used for sample storage and should be fitted with large shelves (50 kg samples). Shelf partitions to be roughly 500 x 1000 mm in size. This will free up the space inside the laboratory that is currently used for sample storage and waste materials;
- The open space immediately outside the laboratory next to the undercover area is meant for sample drying and is being used as a solid waste collection area by the municipal council, containing, old desks and chairs, discarded computers and printers, etc , including very heavy old machinery that would require heavy machinery for removal. This area should be used for the drying of samples, currently done inside the laboratory (see Figure 1). This will free up valuable Laboratory space that may be used for housing equipment in the future.

Figure 2: Sample drying on the laboratory floor

- The working of the bulk samples with spades and the breaking up of soil clods in the confined space of the laboratory generates a lot of dust and noise – this practice is considered both a safety and health hazard to staff and detrimental to sensitive equipment such as computers, scales, and hydraulic presses;
- The area where compaction takes place should be sound proofed. Provision should probably be made to compact moulds outside. This will reduce noise inside the lab and also dustiness. Sample preparation is currently performed within the laboratory, the same area where the

technicians have their desks (see Figure 2). The laboratory staff should be in a fully enclosed room;

- Curing room for treated samples. Currently the soaking tank is outside. Soaking tank should be at 22 to 25 ^{0}C. It probably gets very hot in summer – samples most likely cure at different temperature rates. Potentially, a temperature variation from 15 to greater than 35 degrees Celsius in a day is possible, depending on the time of the year. Current soaking tank is not suitable as it is too deep. A rack should be installed to reduce the total depth of water in the tank. A maximum water depth of 250 mm is adequate for soaking CBR moulds and curing of concrete cubes Potable water should be used in the tank. The tank should be located inside the laboratory where temperature variation is less likely and should be in an air conditioned room.

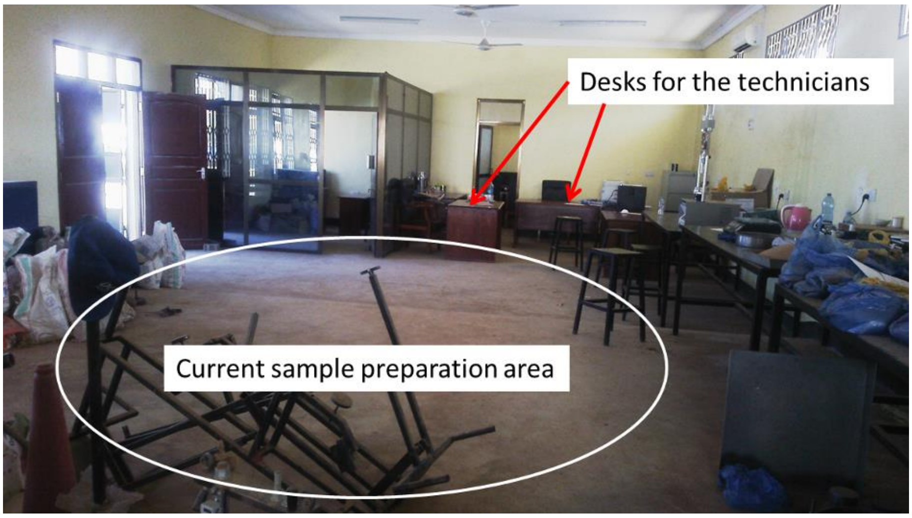

Figure 3: Current laboratory set up and working space

The above issues should be addressed as they will impact on the operations of the laboratory, as well as the health of the staff in the long term. What is required is effective use of the available space, which is adequate for the required laboratory operations.

4 Conclusions and recommendations

The project team has identified a number of issues that should be addressed, in terms of equipment and working space, to ensure effective delivery of services by CMRL as a research laboratory, these include:

- While equipment is now available to conduct routine tests, an assessment of equipment requirements for CMRL to function as a research laboratory was conducted and **a recommendation for procurement of additional equipment was made.** Not all the recommended additional **e**quipment has been acquired as presented in Table 1, and should therefore be acquired.

- The importance of proper management of laboratory equipment, inclusive of maintenance and calibration requirements has been emphasised to the laboratory personnel as it will affect the validity and quality of results.

  It is recommended that the calibration by TBS, equipment maintenance and performance checks are conducted on scheduled basis and systematically as provided in Table 3 and according to Procedure LoGITReC-LAB-2, provided in the accompanying Report on Laboratory Operational Systems and also provided as hard copy with other Laboratory Procedures in a laboratory folder for record.

- New equipment utilisation. When new equipment is acquired and installed, it is not adequate to ensure it is functional; laboratory staff should be in a position to use the acquired equipment.

  It is recommended that laboratory staff is trained in the operation of the triaxial machine immediately following its commissioning.

- It is vital that staff working environment is safe and free from health hazards. The working of the bulk samples with spades and the breaking up of soil clods in the confined space of the laboratory generates a lot of dust and noise.

  It is recommended that staff be provided office accommodation away from storage and sample preparation areas. Storage and sample preparation should be done outside the laboratory.

  It is also recommended that sound proofing be introduced between the current compaction area and the space used for offices.

- Lack of effective use of space. Available space around the Laboratory is being used as a rubbish dump with old desks and chairs, discarded computers and printers etc.

  It is recommended that the area around the Laboratory be cleared of all the waste as soon as possible and more than adequate space will be made available for sample storage and preparation.

APPENDIX A:

Press setting for testing

PRESS SETTINGS

ACV/10% FVT (14 – 10 mm aggregate)		**UCS Rate**	**Cube**
Load Required (kN) **Per 10 minutes**	**Press Rate (N/s)** **(Set Press load rate)**	140 kPa/sec Required	24MPa/min Required
50	83	**Set: 0.140 MPa/s**	**Set: 0.40 MPa/sec**
100	167		
150	250		
200	333		
250	417		
300	500		
350	583		
ACV 400	**667**		
450	750		
500	833		

Example Calculation

Wanted 400 kN in 10 mins = (400 kN/10) **40 kN** in 1 min = (40 kN/60) **0.667 kN** in 1 second:

= (0.667 kN x 1000 N) **667 N /second.**