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OPERATIONAL RELEVANCE OF PROFESSIONAL ENGINEERING DESIGN WITHIN THE CORPS OF ROYAL CANADIAN ENGINEERS

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JCSP 47

Service Paper

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CANADIAN FORCES COLLEGE - COLLÈGE DES FORCES CANADIENNES

JCSP 47 - PCEMI 47
2020 - 2021

SERVICE PAPER

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Word Count: 2,436

Nombre de mots : 2.436

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AIM

1. The aim of this service paper is to confirm the requirement for professional civil engineering expertise in the operational capabilities of the Corps of Royal Canadian Engineers (RCE). The scope is restricted to engineering design on deployed operations. The discussion is structured on the operational functions to demonstrate the broad applicability of the subject. A review of Canadian Armed Forces (CAF) doctrine and recent operational activities is the primary means used in this study. The depth and breadth of civil engineering expertise required of the RCE is considered in the three recommendations provided to ensure the further development of these capabilities.

INTRODUCTION

2. *Duty with Honour* broadly recognizes engineering occupations as among those that, in addition to possessing the core and supporting knowledge of the wider profession of arms, also possess specialized knowledge governed by a civilian profession.[1] Despite inherent linkages between RCE activities and the practice of civil engineering, the regular officer training plan permits entry into the occupation for a wide range of engineering and science educational backgrounds.[2] Furthermore, membership of RCE officers within an engineering regulatory body, such as Professional Engineers Ontario (PEO), is voluntary and not widely pursued. Given these conditions, the relevance of the practice of

[1] Canada. Department of National Defence, *A-PA-005-000/AP-001 Duty with Honour: The Profession of Arms in Canada* (Kingston, ON: Canadian Defence Academy — Canadian Forces Leadership Institute, 2009), 54.

[2] The Office of the Registrar, "Military Occupation and University Degree Compatibility," https://www.rmc-cmr.ca/en/Registrars-office/academic-programmes-and-occupation-compatibility (accessed Jan 23, 2021).

professional civil engineering within the RCE warrants study. Indeed, given similar conditions, United States Army Engineering Officers have contemplated the value of professional engineering education and qualifications to their Corps.[3]

3. PEO defines the practice of professional engineering as:

> any act of planning, designing, composing, evaluating, advising, reporting, directing or supervising that requires the application of engineering principles and concerns the safeguarding of life, health, property, economic interests, the public welfare or the environment, or the managing of any such act.[4]

The RCE's primary role is to assist friendly forces to fight, move and live, while denying the same ability to the enemy.[5] In fulfilment of this role, many RCE officers on operations are likely to find themselves directly involved in engineering design or managing others performing engineering design tasks. This may include acting as the technical authority on behalf of the Department of National Defence (DND) during project management.

DISCUSSION

Sustain

4. The Sustain function demands a wide range of professional civil engineering expertise. The RCE must be prepared to provide any of the infrastructure requirements identified in *B-GL-005-312/FP-201 Force Beddown*.[6] This reference further states that "[t]he analysis, design and assessment of structures must be completed using basic civil

[3] Kelcey R. Shaw, "Professional Certification of Army Engineer Officers," *Engineer* 41, no. 3 (2011), 6-7.

[4] *Professional Engineers Act*, (2020).

[5] Canada. Department of National Defence, *B-GL-361-001/FP-001 Land Force Engineer Operations - Volume 1* (Canada, 1998), 1.

[6] Canada. Department of National Defence, *B-GL-005-312/FP-201 Canadian Forces Joint Publication 3-12.2 Force Beddown*, 1st ed. (Ottawa, Ontario: Canada, 2015), 2-2.

engineering principles and be based on the specifications outlined in appropriate codes."[7] Additional RCE responsibilities include horizontal construction tasks such as road design.[8] The RCE educates and trains Non-Commissioned Members (NCMs) to become subject matter experts (SMEs) to support these requirements. However, similar to civilian practice, this does not negate the professional responsibilities of RCE officers. This is particularly true in regards to the health, safety and environmental risks resulting from design and construction.

5. Recent CAF activities confirm the operational relevance of these doctrinal responsibilities. RCE officers have been involved in an extensive infrastructure program to support the multinational enhanced Forward Presence (eFP) Battle Group (BG) in Latvia since 2016. This program included the design and implementation of several projects including purpose-built structures and site development.[9] The most significant project is the Multinational Headquarters currently under construction in Riga.[10] Similar tasks were conducted in Iraq in 2015.[11] Building Conditions Assessments (BCA) were required, often on damaged or aging structures that had fallen into a state of disrepair, in support of CAF beddown activities in Kuwait, Iraq, Ukraine, Senegal and Mali. In all cases, any design solutions had to be modified to local factors including construction laws, design standards, materials, practices and workmanship. The broad focus on

[7] Canada. Department of National Defence, *B-GL-005-312/FP-201 Canadian Forces Joint Publication 3-12.2 Force Beddown*, 1st ed. (Ottawa, Ontario: Canada, 2015), 4-12.

[8] Canada. Department of National Defence, *B-GL-332-006/FP-001 Insert - Engineers (V2.4)* (Canada, 2000), 8-31 - 8-37.

[9] 1 Engineer Support Unit, "Project 16-ESU-25 Op REASSURANCE: eFP Latvia," https://collaboration-cjoc-coic.forces.mil.ca/sites/1ESUProj/16_ESU_25_S/SitePages/Home.aspx (accessed Jan 30, 2021).

[10] Brandon Pinkney, "Royal Canadian Engineers Constructing the Future in Latvia," https://cmea-agmc.ca/royal-canadian-engineers-constructing-future-latvia (accessed Jan 24, 2020).

[11] The Canadian Military Engineer Association, "1 ESU Designs and Builds Camp Érable in Iraq," https://cmea-agmc.ca/1-esu-designs-and-builds-camp-erable-iraq (accessed Jan 25, 2021).

principles and theory provided by the practice of civil engineering allows RCE officers to adapt to these constraints with an awareness of the associated risks.

6. Sustainment engineering tasks strongly support a requirement for civil engineering competencies. Despite the clear operational relevance, most RCE officers involved in these activities had only limited prior design experience. This limited expertise contributed to delays in implementation, increased costs and imperfect solutions. A small group of NCM SMEs led by officers from 1 Engineer Support Unit (1 ESU) performed the majority of design tasks discussed above. NCM SMEs and officers with specialised engineering education at 1 ESU provide reachback support to these teams. 4 Engineer Support Regiment (4 ESR) also provides an expedient beddown capability that maximizes use of in-service resources and in-situ facilities. Although reliant on pre-designed elements, these solutions are still likely to require civil engineering expertise for certain aspects such as site development, BCAs and the repair or modification of in-situ facilities. Tasks within the Sustain function therefore demonstrate a need for a small number of officers with a depth of professional civil engineering expertise gained through broad experience.

Act

7. The Act function requires a range of civil engineering activities including reconstruction and bridge design tasks. CAF Doctrine identifies Civil Military (CIMIC) reconstruction efforts, including infrastructure repair and development, as a form of influence activity.[12] *B-GL-322-010/FP-001 Stability Activities and Tasks* devotes an entire chapter to the restoration of civil infrastructure and services, identifying potential

[12] Canada. Department of National Defence, *B-GL-320-000/FP-001 Act: The Operational Function* (Kingston, ON: Canada, 2013), 10.

tasks ranging from road repair to the construction of "essential local facilities."[13] CAF doctrine emphasizes these responsibilities are ideally handled by development agencies, however, it also acknowledges this is dependant on the threat environment.[14] Therefore, the integral civil engineering expertise within the RCE is a limiting factor of the CAF's ability to conduct certain stability operations in non-permissive environments. Military engineers were extensively involved in reconstruction efforts that "touched on every aspect of civil engineering" throughout the Canadian mission in Afghanistan.[15] Our allies recognize the value of holding this capability within the Army. Major Martin Naranjo, a U.S. Army Reserve Engineer with two deployments to Iraq, concluded that at BG level the "lack of engineer professionals is an important force management problem" within the U.S. Army.[16]

8. The RCE's role to ensure force mobility in support of the Act function also creates a need to design, evaluate and repair bridges. When classifying civilian bridges for military traffic, or in the design of non-standard military bridges, CAF doctrine recommends an analytical method which is based on civil engineering principles.[17] Although expedient analysis methods are available, these methods are best relegated to urgent tactical situations. The unique load application of military vehicles and their uncertain compatibility with foreign bridge design philosophies make bridge

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[13] Canada. Department of National Defence, *B-GL-322-010/FP-001 Stability Activities and Tasks* (Kingston, Ontario: Canada, 2012a), 6-2-1 - 6-2-8.

[14] Canada. Department of National Defence, *B-GL-322-010/FP-001 Stability Activities and Tasks* (Kingston, Ontario: Canada, 2012a), 6-2-2.

[15] Jean-Olivier Berger, "HAMKARI: Engineers at Work in Kandahar," https://cmea-agmc.ca/hamkari-engineers-work-kandahar (accessed Jan 25, 2021).

[16] Martin J. Naranjo, "Creating a Professional Engineer Functional Area," *Engineer* 40, no. 2 (2010), 20.

[17] Canada. Department of National Defence, *B-GL-361-014/FP-001 Non Standard Bridge Manual* (Kingston, ON: Canada, unknown) 1-4.

classification a requirement in most locations where the CAF operates. The CAF deployment to Latvia resulted in a need to classify all bridges within the eFP BG's area of operations for military traffic. This was a substantial undertaking than included unique designs that weren't easily identified using the expedient classification method broadly taught to RCE officers and NCMs on qualification training.

9. The potential to realize operational effects through reconstruction activities is directly limited by the breadth and depth of civil engineering expertise within the RCE. In both reconstruction and bridge design tasks, the specialized knowledge required could be achieved through a moderate degree of training for individuals who possess an educational background in civil engineering.

Shield

10. The Shield function requires professional civil engineering expertise with respect to field fortifications, protective structures and water supply. CAF doctrine refers to standard NATO terminology in classifying field fortifications as temporary emplacements or shelters requiring only minor engineer supervision and equipment.[18] As such, pre-designed options are available for both all-arms[19] and engineers.[20] For temporary protective structures, CAF doctrine recommends they be "designed to resist specific threats constructed using local materials."[21] This inherently requires engineered solutions. CAF doctrine on water supply emphasizes in-service equipment to support

[18] NATO Standardization Office, *AAP-06 NATO Glossary of Terms and Definitions*, 2020th ed.NATO Standardization Office, 2020), 52.

[19] Canada. Department of National Defence, *B-GL-361-301/FP-001 Field Fortifications - all Arms* (Kingston, ON: Canada, 2017a).

[20] Canada. Department of National Defence, *B-GL-361-301/FP-003 Field Fortifications - Engineers* (Kingston, ON: Canada, 2017b).

[21] Canada. Department of National Defence, *B-GL-005-312/FP-201 Canadian Forces Joint Publication 3-12.2 Force Beddown,* 1st ed. (Ottawa, Ontario: Canada, 2015), 12.

field force requirements with limited guidance on designing modifications to in-situ facilities.[22]

11. With respect to field fortifications, CAF operations confirm a need for greater improvisation in design. Forward Operating Bases (FOB) in Afghanistan in the early 2000's included improvised timber-framed living accommodations that doubled as protective structures. These structures were developed based on available materials and expertise. Many were unable to support the prescribed overhead protection without visible structural duress. The Wainwright training area also became populated with tactical infrastructure due to preparatory training for operations. Many structures in Wainwright were elevated above ground on top of shipping containers. One of these elevated observation posts collapsed in a fatal accident in 2014.[23] The resulting technical investigation identified multiple structural deficiencies including inadequate lateral load resisting system and column support, in addition to excessive loading.[24] The report also noted that the identified deficiencies weren't unique to this particular structure.[25] The need to improvise or alter pre-designed solutions necessitates minimal, but competent engineer oversight. In terms of water supply, the existing source for the eFP BG in Latvia required modification to meet NATO standards for disinfection, resulting in the design of a chlorination system.

12. The risks inherent in improvised field fortifications highlight a broad need for civil engineering expertise within the RCE to conduct fault identification in a supervisory

[22] Canada. Department of National Defence, *B-GL-361-013/FP-001 Water Supply*Canada, 2012b).

[23] Caley Ramsay, "Canadian Soldier Dies Following Accident during Training Exercise in Wainwright," https://globalnews.ca/news/1658223/canadian-soldier-dies-following-accident-during-training-exercise-in-wainwright/ (accessed Jan 23, 2021).

[24] T. L. St-Onge, *1080-1 Technical Investigation - FOB Northgate OP Collapse*, 2-3.

[25] T. L. St-Onge, *1080-1 Technical Investigation - FOB Northgate OP Collapse*, 4.

role. However, this expertise is limited to basic structural theory. The specialized knowledge for protective structures and water supply are required from a smaller group of specialists within the RCE.

Command and Sense

13. Professional civil engineering expertise admittedly plays a minor role within the larger context of the Command and Sense functions. However, it is worth highlighting aspects within these functions that contribute to the RCE capabilities previously discussed. With respect to the Command function, the Canadian Joint Operations Command (CJOC) Joint Engineer (JEngr) is the technical authority on all military engineering matters on operations.[26] Within this role, the CJOC JEngr will advise Commander CJOC on many aspects that fall within the practice of professional civil engineering. CJOC JEngr also provides technical guidance to Task Force Engineers. CJOC JEngr must therefore be supported by staff possessing specialized civil engineering knowledge.

14. With respect to the sense function, the collection of relevant engineering data is aided by a professional civil engineering expertise. For example, with the eFP BG in Latvia there were significant delays in infrastructure development resulting from inadequate understanding of local construction laws, construction industry capabilities and the nature of local materials. Similar challenges were observed in other CAF operations. The role of engineer staff at CJOC and the Canadian Forces Joint Support Group (CFJOSG) in operational and tactical planning and recce strengthens the case for

[26] Canadian Joint Operations Command, *CDIO 10000 (Draft)*, 7.

individuals with civil engineering expertise at these levels. Both organisations have recognized this based on recent experience, however this requirement is not formalized.

CONCLUSION

15. Through a review of CAF doctrine and consideration of several recent CAF operations, it is clear that professional civil engineering expertise remains relevant to the RCE from an operational engineering design perspective. It is also apparent that further developing this competency is beneficial to CAF capabilities across the operational functions. The depth and breadth of professional civil engineering expertise required was evaluated to aid in the recommendations that follow. Generally, there is a broad need for RCE officers to draw on basic civil engineering expertise for a few specific tasks, such as reconstruction, bridge classification and field fortifications. There is also a need for a small portion of RCE officers to develop greater specialized knowledge.

RECOMMENDATION

16. The following recommendations are offered to further develop professional engineering expertise within the RCE:

a. *Education*. This analysis confirms the broad applicability of a civil engineering education to RCE tasks. An assessment of the benefits to the RCE of drawing from a diverse range of educational backgrounds was beyond the scope of this paper. Further study should be conducted to determine what factors might moderate any recommendation to privilege a civil engineering background in officer recruitment and development.

b. *Training*. RCE officers must maintain broad expertise in widely applicable specialized knowledge such as reconstruction, bridge classification and

improvised field fortifications. These skills can be strengthened with minimal effort through professional development activities such as a day exercise devoted to theory and practice of bridge classification. Developing greater depth of civil engineering expertise within a small pool of RCE officers is also required. This is best achieved through practical experience in design engineering in foreign locations under the supervision of qualified professional engineers. Achieving this is challenging given the investment in time and money any potential solution would necessitate. However, this experience will improve delivery time and minimize deficiencies in the development of deployed infrastructure. Therefore, further study of potential solutions is warranted.

c. *Employment*. The employment of individuals with professional civil engineering expertise within both CJOC and CFJOSG should be formalized. This will aid in the collection of engineer intelligence at the operational and tactical level relevant to potential engineering design activities.

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