# Typical roles and activities of Civil Engineering Technicians and Technologists in their first three years after graduation.

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# Structured Abstract

**CONTEXT**
Engineering Technicians and Technologists comprise an important part of the civil engineering industry. Technicians and technologists typically complete the New Zealand Diploma in Engineering (NZDE) or Bachelor of Engineering Technology (BET) respectively. The Australian and New Zealand Standard Classification of Occupations (ANZSCO) lists and describes occupation groups that graduates may fill and IPENZ provides a good general description of the competencies required of these graduates. However these sources do not go into the detail needed to properly align education with the skills and knowledge that technician and technologist graduates need in the first few years of their careers. There is also limited research that distinguishes between the variety of roles that technicians and technologists fulfil in the civil engineering industry and the activities that each role entails.

**PURPOSE OR GOAL**
The purpose of this research was to determine what roles NZDE and BET civil engineering graduates typically fulfil, what activities they undertake in the first few years after graduation and how the current curriculum could be improved to better enable graduates to transition from education to engineering practice.

**APPROACH**
An online survey was sent to all former students who had graduated from the Unitec NZDE (Civil) and BET (Civil) courses between 2010 and 2012. This survey included questions related to the industry and fields of engineering that they worked in, the activities they undertook and how well they thought Unitec had prepared them for industry. The survey information was analysed to determine more specific roles and to provide a profile of each role. It was found that these roles closely aligned with those developed in ANZSCO. A series of interviews with graduates followed to provide more detail on the roles and activities that the graduates undertook to develop a better understanding of the nature, associated activities and typical skills and knowledge development within each role.

**ACTUAL OUTCOMES**
The online survey found that most (61%) BET graduates work in the consultancy industry with the rest working in the construction industry (32%) or for the local Council (7%). In contrast the majority (71%) of NZDE graduates work in the construction industry while the rest work in the consulting industry. Most of the survey respondents seemed to fall into one of six roles namely Site Engineer, Draftsperson, Structural Engineer, Infrastructure Engineer, Laboratory Technician or Council Officer. Most of the survey respondents and interviewees were satisfied with the preparation for industry that the Unitec programs had provided but suggested some possible improvements.

**CONCLUSIONS/RECOMMENDATIONS/SUMMARY**
Research was undertaken to determine the roles and activities of graduates from the Unitec BET and NZDE programs and to determine how well the Unitec programs aligned with the needs of these graduates. The programs appear to be providing the needs of the graduates but they could be improved with additional elective courses and a construction management specialisation in the BET program.

**KEYWORDS**
Technician, Technologist, Graduate, Roles

# Introduction

The transition from education to industry is a significant event in a graduate's career. One of the aims of an engineering education program is to provide graduates with the skills and knowledge they need to make this transition and then develop them as they progress in their career.

Engineering Technicians and Technologists comprise an important part of the civil engineering industry. Technicians are able to solve conventional well-defined problems using standards and codes of practice while technologists have a higher level of training enabling them to solve more broadly defined problems (IPENZ, 2009). These well-defined and broadly-defined problems comprise a significant part of normal day-to day engineering practice.

Technicians typically complete the two year New Zealand Diploma in Engineering (NZDE) program while technologists complete the three year Bachelor of Engineering Technology (BET) program. Both go on to work in the engineering industry but the actual roles that each group goes to is only generally defined and it is unclear whether there is actually a difference in roles fulfilled by both groups.

While industry plays a major part in the development of engineers, it is the skills and knowledge they learn in formal education that forms the foundation of the graduates' development. Therefore it is important that the education students receive is aligned to what they will need in their transition to, and development as, an engineer. To enable this, educators need to understand what it is that technicians and technologists do in practice and the knowledge, skills and attributes that graduates need to enable them to quickly transition into their new roles in the engineering industry.

The objective of this research was to identify what roles graduates of the Unitec civil engineering programs filled and what activities they carried out with the aim of identifying possible ways in which the programs could be improved.

# Literature Review

In New Zealand, IPENZ defines both technician and technologist requirements in their graduate competencies table (IPENZ, 2009) which sets out ten competencies covering technical foundations, personal skills and supporting knowledge. The roles of technicians and technologists are also well defined in the Australian and New Zealand Standard Classification of Occupations (ANZSCO) (Statistics New Zealand, 2012). ANZSCO has several occupation groups (Unit Groups) that are applicable and which provide descriptions of the tasks each occupation typically carry out. While these resources provide general role and attribute descriptions, they do not set out what the graduates actually do, what they need to know and how they develop as engineers.

Research on actual engineering practice is sparse (Trevelyan and Tilli, 2007) and no recent research related to engineering practice as carried out by civil engineering technicians and technologists has been found. However some insights into general engineering practice can be made from the review of existing literature however it should be noted that most of this research relates to university graduates not technicians and technologists.

Trevelyan and Tilli (2007) note that engineering work requires a significant amount of on-the–job training so many graduate engineers experience a steep learning curve when they start work (Martin et al, 2005; Trevelyan, 2012). Most graduates felt they were up for the challenge because of the skill, knowledge and experiences they had at university (Martin et al, 2005). Male et al (2011) noted that there is an increasing focus on "attitudinal competencies" which allow the graduate to have the attitude and confidence to accept and thrive on the challenges they encounter when first entering the engineering industry. Martin

et al (2005) mentioned the importance of forming relationships in the workplace to help graduate engineers make the transition with several graduates noting that working in an open plan working environment with experienced engineers meant they were able to ask questions and quickly develop the skills and knowledge they needed.

One of the other main recurring themes is that engineering is not just the practice of technical activities, such as design and analysis, but also includes non-technical activities such as communication and management. Trevelyan and Tilli (2007) observed that graduate engineers spend approximately 60% of their time in communication type activities. Bodmer et al (2002), Newport and Elms (1997) and Male et al (2011) all found that experienced engineers rated communications and other interpersonal skills above technical skills although they all noted that technical skills and knowledge were an essential requirement for engineers. Male (2012) suggests that the seemingly lesser rating of technical skills may be because engineers often do not notice when they are using their technical knowledge. That is, the decisions and actions they take in seemingly non-technical activities, such as management, are informed by their technical knowledge and skills. Newport and Elms (2005) and Trevelyan and Tilli (2007) also emphasize the importance of management related skills, such as planning, organising, coordinating and supervising, which are intertwined with technical engineering work.

One aspect of engineering education was how well the syllabus corresponded with the practice of engineering. Several researchers (Trevelyan 2012; Bodmer et al, 2002) noted that this aspect was more important to practising engineers than teaching staff who tend to focus on engineering knowledge over engineering practice. It is suggested that the practical focus is especially important with technician and technologist education where the graduates are expected to be work ready. Martin et al (2005) noted that several of their interviewees mentioned the value of being exposed to real engineering environments while studying through site visits and vacation work.

While the available research is not directly related to Unitec graduates it does raise some questions as to the relative importance of technical and non-technical activities, how graduates transition into the work environment, how they learn what they need to function in their new roles and what they felt Unitec could have done better to prepare them for their industry.

# Methodology

The research was carried out in two stages. In the first stage an online survey was sent to 208 recent (2010 to 2012) graduates of the Unitec BET and NZDE programs. The online survey contained multiple choice questions on the type of organisation they worked for, the field or fields they worked in and the activities that they typically undertook. The survey also provided open questions allowing respondents to comment on the relevance of their program to what they were doing in industry and how the programs could be improved. The survey data was reviewed to develop an understanding of the typical activities undertaken by graduates and the different general roles they filled in the civil engineering industry.

The survey was followed with several rounds of interviews. The first round of interviews was of seven survey respondents. These graduates had typically been working for one to three years. A second round of eight graduate interviews and two written questionnaires was carried out in July 2014. These interviewees were graduates from the 2013 programs and were typically in the first year of their career. The interviews all had the same basic format but these were customised to the graduates' role to provide more detailed information on specific roles.

A qualitative analysis of the recorded interviews was carried out to check the validity of the roles identified in the online survey, to provide more detail on what each role entailed, to identify how the graduates grew into their new roles and to determine how the Unitec programs could be improved to aid this transition.

# Results

## Online Survey

Forty five students responded to the online survey resulting in a 22% response rate. An analysis comparing the grade point averages, gender and ages of the respondent group with the whole graduate group indicated that both groups had a similar distribution indicating a good sampling validity.

### *Organisation Type*

Figure 1 shows the distribution of the graduates by organisation. It indicates that the majority of NZDE students (73%) end up in the construction industry while the majority of BET graduates (61%) work for consultancies.

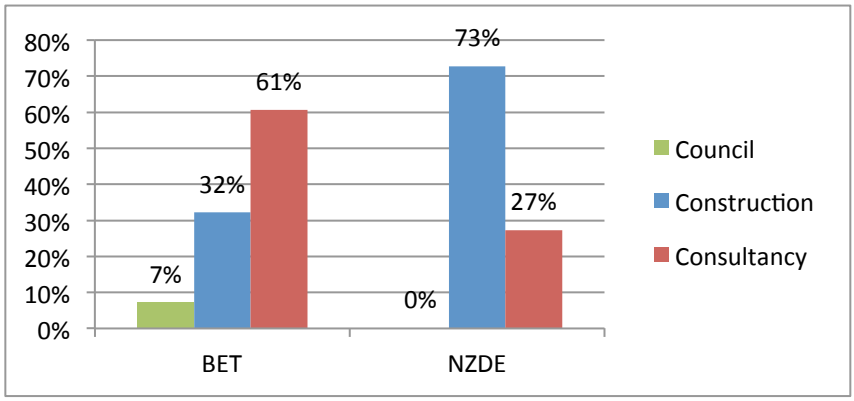


**Figure 1 - Employer Organisation Types**

### *Field*

Figure 2 shows the civil engineering field that graduates work in.

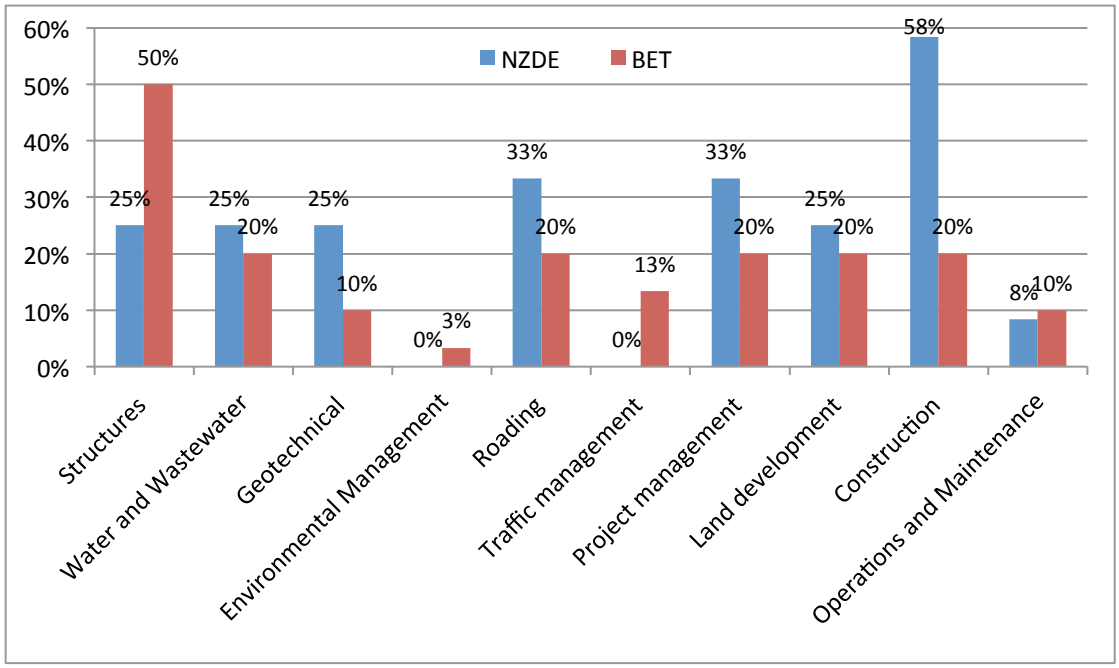


**Figure 2 - Graduate Fields**

The fields offered included the conventional fields such as structures and geotech but other less conventional fields such as project management, construction and land development were also offered to provide a better idea of what the graduates actually did. Respondents were able to select more than one response and so there are several graduates who responded to more than one field.

*Graduate Activities*

Figure 3 shows graduate activities arranged by organisation type. The main activities are CAD work, Design, Inspections, Project Management and Communication.

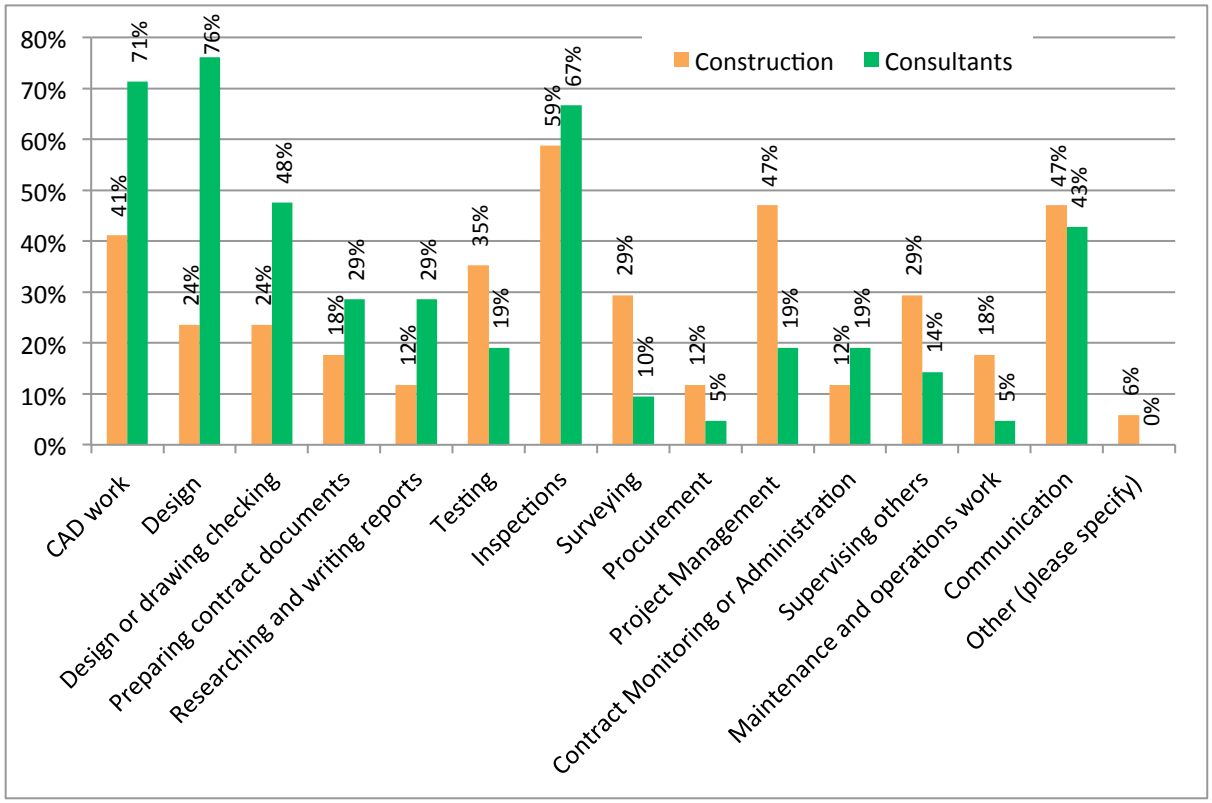


**Figure 3 - Graduate Activities by Organisation Type**

*Roles*

The survey data was used to develop a series of role categories that had simular functions and activities. These were found to align closely with relevant ANZSCO occupations so the roles and terms used for them were modified to align with the ANZSCO occupation descriptions where appropriate.

The general roles identified were:

- ***Site Engineers*** who work for construction companies doing front-line management activities. All of the interviewees in this group work full time on site organising, controlling and coordinating the construction work. Initially this role aligns best with the ANZSCO description of a “Building Associate” (ANZSCO Occupation Code 312112). However, they quickly assume more responsibility and carry out more complicated activities and so move to a role more aligned with the “Engineering Manager” (ANZSCO Occupation Code 133211) occupation within a year or two of commencing work.

- ***Draftpersons*** who usually work for consultancies preparing drawings for civil engineering works based on designs produced by design engineers. This role aligns well with the "Civil Engineering Draftsperson" occupation (ANZSCO Occupation Code 312211).
- ***Structural Engineer*** who design and supervise the construction of structures, usually buildings. These engineers may also produce their own drawings. This role best aligns with the "Structural Engineer" occupation (ANZSCO Occupation Code 233214).
- ***Infrastructure Engineer*** who design, produce drawings for and supervise the construction of infrastructure systems such as roading, water, wastewater and stormwater systems. Most of the survey respondents fitting into this role were designing services for new subdivisions. This role best aligns with the "Civil Engineer" occupation (ANZSCO Occupation Code 233211).
- ***Laboratory Technician*** who work for consultancies or specialist labs doing onsite and laboratory testing of soils and materials. This role best aligns with the "Civil Engineering Technician" occupation (ANZSCO Occupation Code 312212).
- ***Council Officer*** who works for local councils or council controlled organisations in managing projects, quality control or other management roles delivering council projects and services.

**Interviews**

The interviewees generally represented most of the main groupings identified in the survey with five Site Engineers, one Draftsman, one Structural Engineer, five Infrastructure Engineers and two Council Officers. No Laboratory Technicians were interviewed but one of the Site Engineers had started his career in that position and was able to provide some information on that role.

Graduates working in consultancies typically worked in the same office as their mentors who allocated them work and answered their questions. Most moved to their own simple projects within a few months with projects getting more complex as they developed.

Site Engineers typically started doing inspections and testing as this allows them to become familiar with construction documentation and processes while still doing useful work onsite. They may also be involved in health and safety management early on by contributing to the running of toolbox meetings and doing regular audits. Within months they are typically becoming involved in planning and implementing work activities doing activities such as coordinating work teams and ordering materials. Later they become involved in higher management activities such as preparing variation and progress payment claims, cost management and programming.

When asked about the Unitec programs, most said they had prepared them for industry with several of the Infrastructure Engineers highlighting an Urban Hydraulics course run by a practising engineer as being especially relevant and useful. Most did not have an immediate answer when asked what they considered was not useful with most eventually saying that while they did not use all of the skills and knowledge they had learnt, they could see that it would be useful to others.

The most common suggestion for improvements was for more site visits and exposure to industry. Some of the interviewees had worked in the engineering industry over the holidays or worked full time when studying and all of them mentioned the value of having practical experience. One common comment was that the program content all started to make sense once they started working.

# Limitations

There are a variety of factors that limit the applicability of this research. Firstly the research looked at a cross section of graduates for the Unitec programs and there were probably some activities or roles that were missed. Secondly the makeup of graduates from the programs may be skewed by the presence of other education providers who offer more field specific education and/or correspondence courses in the BET and NZDE programs which may be more attractive to students in some roles such as roading design. Thirdly most respondents and interviewees worked in the Auckland area which has a civil engineering industry that is larger and more specialised than most other areas of New Zealand.

# Discussion

The online survey shows a distinct difference between positions filled by the BET and NZDE graduates. Most (61%) BET graduates work for consultancies with a lesser number (32%) working in construction while the reverse happens with the NZDE graduates with most (73%) working in construction and the rest working in consultancies. This large number of NZDEs in construction offers an opportunity of expanding the BET qualification to include a specialisation in civil construction to allow these graduates to access relevant education programs as they progress in the construction industry.

The roles in consultancies seem to vary with most BET graduates, but only one NZDE graduate, doing design. This indicates that the two qualifications are viewed differently by industry with consultancies recognising the ability of BET students to do routine design work.

Most Consultants selected CAD work, design and design checking as expected however it is not clear whether these respondents were draftspeople doing a few simple designs or engineers doing their own drawings. The amount and complexity of the design work undertaken by graduates seems to vary across firms with some firms using BET students in design roles and others maintaining a strict separation between draftspersons and engineers with draftpersons being NZDE or BET graduates and engineers being BE graduates. It appears that the infrastructure field is more likely to have Unitec graduates doing design than the structural field.

There were also a significant number of Site Engineers who also selected CAD work in the survey and from the interviews it appears that these graduates are producing as-built drawings, managing drawing sets and doing other CAD work that is required. Several interviewees had also been tasked with learning and implementing new software packages to improve the efficiencies of the site planning and management processes.

Inspection was selected by a significant percentage of graduates working in both the consulting and construction industries. Inspection was expected to be one of the core activities of Contractors but it was surprising to see that most Consultants also do inspections. This indicates most Consultants do get out of the office and go to site to do the inspection as well as doing the office type activities such as CAD and design.

The Procurement, Project Management, Contract Monitoring and Supervision activities were included to provide a breakdown of management type activities. Most of the respondents selecting these activities worked for construction companies indicating a significant management component to the role of the Site Engineers.

The “Communication” activity was selected by many of the respondents in both Consultant and Contractor groups confirming the importance of this activity mentioned in previous research. All of the interviewees mentioned that they spent a significant amount of time communicating with their bosses, other engineers, clients and workers mostly in direct face to face meetings, emails and telephone calls but also with letters and short reports. This agrees with the observations made by Trevelyan (2010) that novice engineers spend around 60% of their time communicating both verbally and in writing.

# Recommendations

While this research is limited in its scope, it still offers some insights into how the NZDE and BET programs could be improved to make them more relevant to the Auckland civil engineering industry.

One improvement is to add a course focused on civil engineering construction to the NZDE program given that most NZDE graduates will work in the construction industry. The program originally had a "Construction Practices" course but this was removed to make room for a capstone project. This issue became obvious in the early stages of this research and Unitec has responded by adding a compulsory Construction Practices course to its 2015 NZDE program

Another response to the high number of NZDE graduates in the construction industry could be to develop a civil engineering construction speciality in the BET program. This would allow NZDE graduates in the construction industry to continue their education in a field that is relevant to their career path. This was a need identified by some of the interviewees who noted that while there are good building construction management programs available in Auckland, there were none that focused on civil engineering activities such as earthworks and drainage.

Both programs could also benefit with the addition of an infrastructure design course early on in the program. After structural design, the second highest number of graduates in consultancies designed infrastructure for new land development projects. This is distinct from being specialist water or roading design engineers which is what the current program structures seem to be based on. It is suggested that an early infrastructure design course based on the use of council standards to design roads, water, wastewater and stormwater system will better align the programs with one of the main civil engineering activities in Auckland, will give the students a marketable skill earlier which may allow some to start work while they are still studying and will also give them a big picture view of infrastructure before they go on to do specialist water and roading courses.

One finding from this research was the importance of communication and CAD drafting however the NZDE course combines these into only one course – Technical Literacy. There is another drawing course after but the communications and drawing content of the program still does not reflect the importance of these skills as identified in previous research on important graduate attributes. It is suggested that communications should be one course and drafting should be two full courses to better provide NZDE students with these important skills.

It is acknowledged that adding new courses into an already packed 2 or 3 year program would restrict the elective options and require other specialist compulsory courses to be changed to electives resulting in a move to more general broader civil engineering programs. It is suggested that this is what these programs should be given the relative time available and the more general functions of technicians and technologists. In fact a few interviewees did note that the field they ended up in was different from the specialities they studied and in retrospect considered that it was a lottery as to whether the speciality chosen matched the field a graduate actually ends up in.

# Conclusions

The NZDE and BET programs delivered by Unitec provide students with the opportunity to work in the civil engineering field doing the more routine type engineering activities. The programs are focused on providing work-ready graduates so most graduates are able to become productive members of their teams within months of starting work.

This research has provided some insights into the roles that Unitec graduates fill after graduation. Most of the NZDE and almost a third of the BET graduates work in the

construction industry as Site Engineers providing front-line management for civil engineering construction projects. The majority of the remainder work in the consulting industry doing drafting, design and inspection type activities with BET graduates being more likely to be doing design type work. The consultant group is split between the structural and infrastructure fields with most of the latter being involved in land development projects.

Most of the survey respondents and interviewees were satisfied with the Unitec BET and NZDE programs and the issues raised in the survey and interviews were restricted to only one or two people and were generally minor. However, there is room for improving both programs by adding new courses to provide better alignment with industry practice and providing more work ready graduates.

The civil engineering industry appears to be very familiar with the capabilities of these graduates and is able to effectively manage the graduate's transition from student to engineer. The graduates who were interviewed expressed satisfaction with their both their decision to be a civil engineer and with the field they were in. They were keen to share what they were doing, excited about their future and eager to develop as engineers.

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