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# A Project Based Assessment of the Foundation Engineering Course for Large Class Sizes

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ABSTRACT: The Engineering Council of South Africa has a mandatory requirement that all the courses of the Baccalaureus Technologiae degree shall comprise a project. The passing of this project is required in order to pass the course. The purpose of such projects is to assess whether a student has understood the knowledge imparted and is able to appropriately apply it. Allocation of a different project to each learner in the case of large class sizes poses a practical problem. Hence, group projects are opted for. Furthermore, the fair evaluation of the group projects and allocation of specific marks to each member based on actual contribution poses a challenge, as it is not acceptable to allocate the same mark to every group member. This paper proposes an original comprehensive system for, firstly, assessing the application of knowledge and secondly, fairly assessing group projects and allocating specific marks to the individual members. This system was implemented in the Foundation Engineering IV course, at the University of Johannesburg. The system was successful as 91 % of the learners achieved the outcomes. In addition, the individually allocated marks appeared fair as none of them were queried.

*Keywords: Engineering, Geotechnical, Assessment, Projects*

## 1 Introduction

The Engineering Council of South Africa (ECSA), which accredits academic qualifications for the purposes of professional registration, has imposed a mandatory requirement that all courses of the Baccalaureas Technologiae: Civil Engineering degree should comprise a project. Project-based Learning (PBL) is an effective practice (Powell, 2004; Jackson et al., 2012). The objective of such projects is to assess the appropriate application of the course content taught. Furthermore, this project component contributes a minimum of 30 % towards the course final mark. Failure of the project (a mark less than 50 %) results in failure of the course, irrespective of the marks obtained in the other assessments.

Allocation of a different project to each learner in the case of large class sizes (comprising approximately 150 learners) poses a practical problem, as there are not enough topics to allocate a significantly different topic to each student. This problem is exacerbated by the fact that new topics need to be introduced every year that the subject is offered, to avoid possible copying of previous projects. In addition, the marking of a large number of projects by the lecturer, which is mandatory (i.e. no marking assistance is permitted), would not be possible in the timeframe available.

Furthermore, if group projects (instead of individual projects) are opted for, the fair evaluation of the group projects and allocation of specific marks to each member is a challenge, as it is not acceptable to allocate the same mark to each group member. Hence, a system is required that fairly assesses each member's contribution.

The purpose of this paper is to propose original comprehensive systems for, firstly, assessing the application of knowledge and secondly, fairly assessing group projects and allocating specific marks to the individual members. These systems were implemented in the Foundation Engineering IV course, at the University of Johannesburg.

## 2 Literature review

### 2.1 Project assessment

Geotechnical Engineering courses (including Foundation Engineering) are generally assessed by means of one or more of the following methods: tests, assignments, examinations, laboratory reports, designs or other type of projects. Gratchev & Jeng (2018) conducted research considering soil mechanics students over a 3-year period, where they gave students the option to choose between project-based and traditional assignments. Their research concluded that, although the marks obtained by the project-based and traditional assignment student groups were similar, students who selected the project-based assignment reported higher engagement with the learning process. Kunberger (2013), who converted a Geotechnical Engineering course from a lecture to a project-based approach, also reported that students gave positive comments and that their performance met the stated objectives.

Scoring guides for marking of the projects are specifically compiled, depending on the nature of the project. Hence, such scoring guides are not standardised.

### 2.2 Member specific mark allocation

Peer review systems may be used as a sole or partial basis for allocating project marks to group members.

A number of researchers have relied on peer evaluation methods to allocate marks to individuals in a group, including Rafiq & Fullerton (1996), Baker (2008), Wang & Vollstedt (2014) and Van Hattum-Janssen & Lourenço (2006).

Triantafyllou & Timcenko (2014) provide a literature review of project-based peer assessment systems, applicable to engineering group projects.

Peer review systems have been deemed not ideal, as the students are too inexperienced to evaluate their peers (Jassawalla et al., 2009). Furthermore, these methods do not evaluate specific skills and do not render feedback to the students (Saavedra & Kwun, 1993). In addition, the peer assessment system is also characterised by inevitable bias introduced by students during the assessment process (Li, 2001).

Others have devised assessment systems that are based on peer assessment as well as assessment by the instructor, either by assessing individuals (Wengrowicz et al., 2017) or by assessing the project report and presentation (Hersam et al., 2004).

Wang and Vollstedt (2014) developed an automated method. This method calculates a mark for the individual by considering the performance of the individual relative to the other group members in other individual assessments. It assumes that a student who performs better in individual assessments should obtain a relatively higher mark for the group project. The authors of this model did not recommend its global implementation, but rather that it be used to flag anomalous cases.

The above methods do not rely on the sole expertise of the course presenter to mark the report and allocate marks to individuals based on their involvement. Hence, a new method for allocating individual marks from a group project is proposed below.

## 3 Details of the Foundation Engineering IV course

### 3.1 General

The Baccalaureus Technologiae: Civil Engineering degree is offered, by a number of national universities in South Africa, in a number of specialist fields including structures, transportation, water and management. The field of specialisation is based on the majority of the subjects selected. At the University of Johannesburg, the Foundation Engineering IV course is compulsory for all the specialist fields.

The lectures for this course amount to approximately 40 hours, presented as a series of three-hour weekly lectures, over a semester.

### 3.2 Course syllabus

The course syllabus comprises of the following main sections.

- Site investigations: Stages of investigation, SAICE (2010) Site Investigation Code of Practice, GFSH-2 (2002): Geotechnical Site Investigations for Housing Development, field tests and laboratory tests.
- Bearing Capacity: Including theories and methods.
- Settlement: Theory, classical and elasticity based methods of prediction.
- NHBRC (2014) Manual: (including residential site classification) and heave prediction methods.
- Piling: Types and application, capacity (including uplift and lateral loads), settlement and pile groups.

Successful completion of this module should equip the learner with the fundamentals, including theory, methods of analysis and knowledge of laboratory tests to apply scientific principles and the engineering judgment required to design a foundation or foundation system.

### 3.3 Assessment

This module is run on a continuous assessment basis. Hence there is no final examination.

The course is assessed by two open book tests and a project. The project counts 30 % towards the final mark. A minimum of 50 % is required to pass the project. In addition, passing the project is a requirement to passing the course. In accordance with ECSA's requirements, at least one of the tests has to be moderated externally (by an industry-based expert).

The Moderator is sourced and appointed by the course instructor. In the case of at least one test, the question paper has to be moderated (prior to it being written) and at least 20% of the total number of scripts (139 registered students in 2019) have to be reviewed. The scripts to be moderated have to be selected from top-performing, average-performing and low-performing students and have to be signed by the Moderator. The Moderator is also available to assist in any other relevant way (e.g. cases of dishonesty). The project is also discussed with the Moderator before being detailed in the study guide. In this course, the projects were also discussed with the Moderator after being marked. Generally, the best, average and fail projects are reviewed by the Moderator, devoting more attention to the projects that failed, as failing the project means failing the course. In this course, the Moderator spends approximately 15 hours (in a semester) on the above tasks. Moderators are remunerated at a nominal rate, however, they undertake this appointment primarily for the purpose of giving back to the profession. Often Moderators refuse to be remunerated. Incidentally, they may record the hours spent as Continuous Professional Development (CPD), which is required for renewal of professional registration.

## 4 Project details

### 4.1 General

According to ECSA, projects should involve the "solution of real/industrial/applied problems using fundamental principles that underpin current technology".

At the first lecture students were given the opportunity to place their names in a group. A total of 23 groups, each comprising of six members, were formed.

## 4.2 Brief

In 2019, each group was randomly allocated a different typical soil profile (and its geographical location), from a different region in South Africa. The allocation of the different profiles was done on a random basis. These profiles were taken from reports of various geotechnical investigations, in which the author of this paper was involved.

An example of a relatively complex soil profile, allocated to one of the groups, is shown in Figure 1.

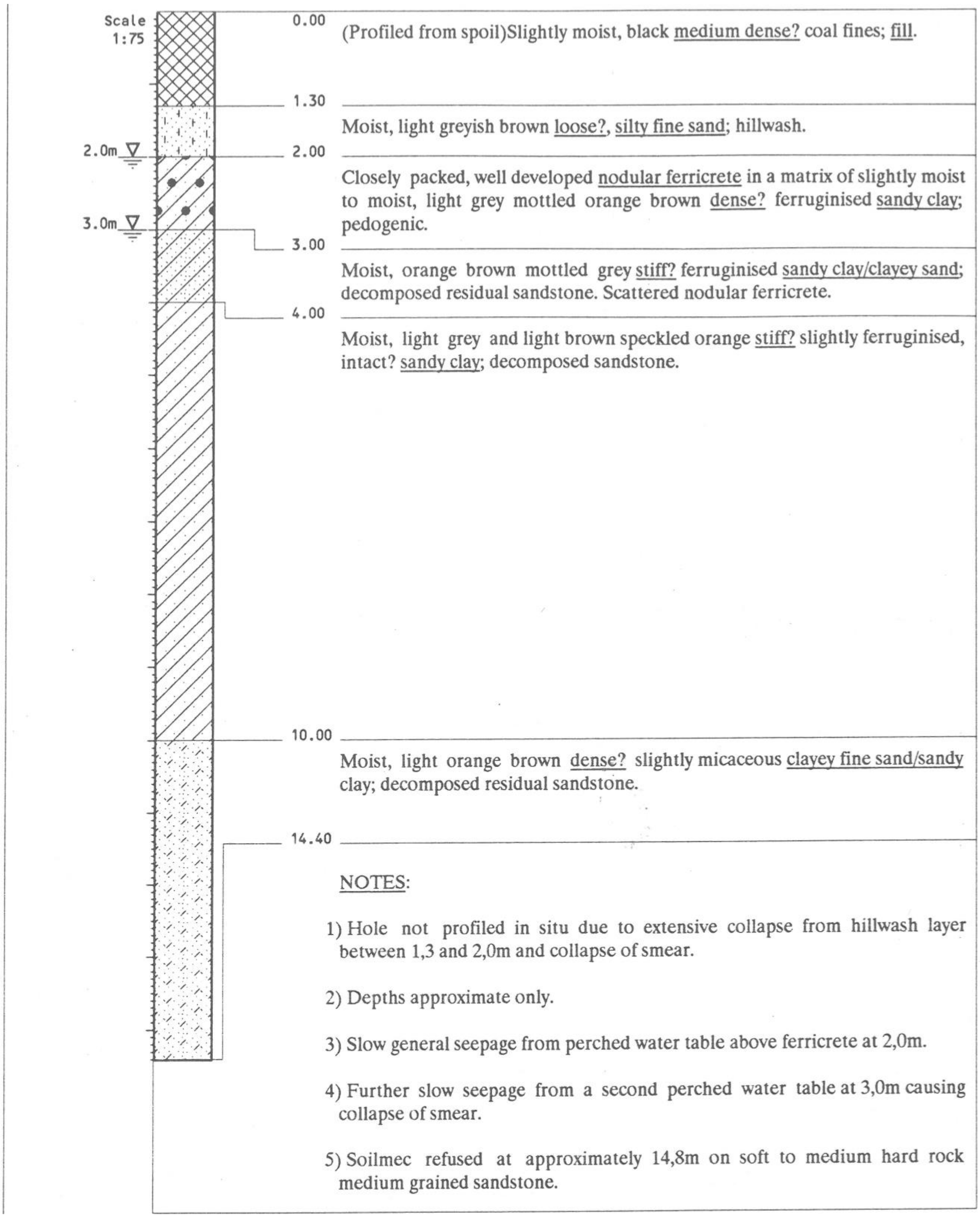


**Figure 1. Example of a relatively complex soil profile**

In the soil profile in Figure 1, question marks appear alongside the consistencies of the layers below 1.3 m. The reason for this is that the consistencies of these layers were determined from the excavated soil and not in the usual manner (using a geological pick when in the hole) as, due to extensive collapse, it was not safe to descend into the hole. However, in this case the students were requested to regard the questionable consistencies as being actual.

The 23 soil profiles varied in complexity and were taken from reports of investigations which were conducted in three of the nine National Provinces of South Africa, namely Gauteng, Free State and Mpumalanga.

All the projects were based on geotechnical aspects for a single-storey housing development.

Each group was given a different area size for their housing development site. These areas, for the various groups, ranged from 2 to 500 hectares.

On the basis of the soil profile and area size allocated, each group was requested to prepare a report.

The report was to comprise the following four aspects.

- Details of the geotechnical investigation that should be conducted for the housing development. This should include, but not necessarily be limited to, details of the fieldwork (e.g. type and number of test pits and type and number of field and/ or laboratory tests).
- For the profile allocated, reasonable horizon properties should be assumed (and their source justified) for the appropriate tests that would have been conducted in an actual investigation.
- Using the reasonable horizon properties (above), a relevant analysis, should be conducted. This analytical component of the report should include evidence of the application of knowledge acquired during this Foundation Engineering course and prior Geotechnical Engineering courses. Therefore, the analytical component of the report should include calculations of bearing capacity, settlement and heave etc. (where applicable).
- On the basis of the analysis, the Site Class and relevant founding options for the housing development should be recommended.

Reports should be typed and well presented. A lengthy final report is not expected (maximum 5 pages excluding appendices). The report should explain each group's project, the background and theory if relevant, summarise the findings of the group's work and include some discussion/interpretation of the results. Submission of reports by individuals who preferred to work on their own was not an option.

The projects for the following years will be different from the 2019 project, by changing the following details:

- The nature of the proposed development. In 2019, the project was based on a single-storey housing development. This could be amended to a very different development, for example a multi-storey office building.
- Soil profiles allocated to groups. The author is in possession of hundreds of soil profiles, from over 70 geotechnical site investigations, that may be used.

## 4.3 Assessment

### 4.3.1 Report Assessment

The assessment of the technical content of the group report was done in accordance with a scoring guide, which considered seven main criteria, shown in Figure 2.

The marking was conducted by the course presenter (author of this paper) and was not based on any form of peer review system.

| Description of Criteria | Maximum Marks | Mark Obtained | Comments |
|---|---|---|---|
| Understanding of Project Objectives and Structure of the Report | 10 | | |
| Investigation Details and Relevance | 20 | | |
| Assumed Properties and their Justification | 10 | | |
| Analysis and Application of Knowledge<br>*(Including calculations e.g. bearing capacity, settlement and heave).* | 20 | | |
| Discussion and Recommendations | 15 | | |
| Initiative, Creativity and Originality | 10 | | |
| Presentation | 15 | | |
| **TOTAL =** | | | **100** |

**Figure 2. Report marking scoring guide**

### 4.3.2 Allocation of specific marks to group members

The introduction to the report included a paragraph stating which part of the report each group member was responsible for. It was not acceptable to state that all members were responsible for all parts of the report. In addition, the Agreed Group Relative Contribution Assessment Sheet shown in Table 1 was included in the report. The purpose of this sheet was to appropriately allocate marks to each group member based on their individual contribution and the project report mark.

Before filling in the sheet below each student was requested to conduct a self-assessment, by giving themselves a mark out of 10 for each of the four categories. Thereafter, the group was to meet and on the basis of the self-assessments, discuss and agree on each person's mark for each category. Although, thus far, this system includes elements of peer review, it differs from peer review systems in that the score of each individual had to also be agreed upon by the individual being rated.

**Table 1. Agreed group relative contribution assessment sheet: a sample[1]**

| Activity | Group Member Name or Initials | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| Attendance of Meetings (max 10) | 10 | 10 | 10 | 10 | 10 | 10 |
| Intellectual Contribution (max 10) | 10 | 8 | 7 | 10 | 9 | 7 |
| Research and Analysis (max 10) | 10 | 8 | 9 | 9 | 9 | 8 |
| Report Compilation (max 10) | 10 | 9 | 7 | 8 | 8 | 7 |
| Total | 40 | 35 | 33 | 37 | 36 | 32 |

[1] scores correspond to the group that earned the highest report mark (96 %)

The mark of each group member was calculated by multiplying the project mark by the ratio of each group member's score to the maximum score obtained by any member. Hence, for example, as the maximum score obtained was 40, the project mark allocated to, for example, Member "C" was 33/40 x 96 % = 79 %.

In certain cases, the mark calculated for each student was further adjusted by considering both the explanation given in the introduction (regarding which member was responsible for the various components of the report) and the marks awarded for the seven criteria in the marking scoring guide (Figure 2). Such rare adjustments were generally made in the case of members who were responsible for a task associated with a criterion in the scoring guide that obtained an excellent or a poor mark.

The proposed system awards individual marks based on both effort and content produced.

The projects were viewed by and discussed with the Moderator, before being released to the students.

# 5 Discussion

## 5.1 Group report results

Figures 3 and 4 show the marks pertaining to the seven criteria constituting the marking guide for the reports that obtained the highest (best), average and lowest (worst) marks which were 96 %, 60 % and 32 %, respectively. Only two of the groups failed the report and consequently failed the course.

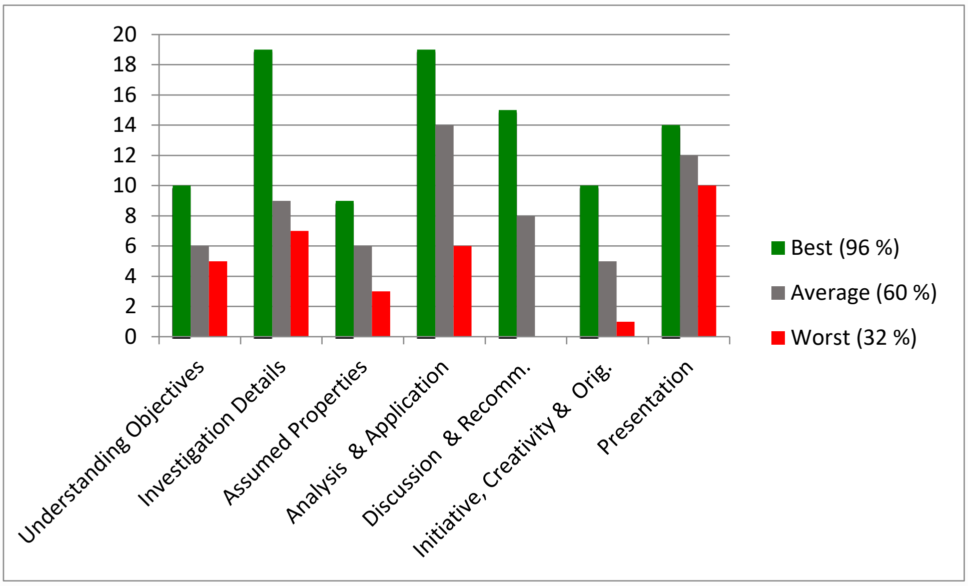


**Figure 3. Marks obtained for specific assessment criteria of reports**

The best and worst reports are briefly discussed in Sections 5.1.1 and 5.1.2.

### 5.1.1 Best report

The best report was excellently written, earning a mark of 96 %, for the following reasons.

- The introduction included a detailed table specifically indicating which group member or members were responsible for compiling the various aspects of the report.
- The report was very well structured, like a typical geotechnical investigation report, and included sections briefly describing the site topography, geology, hydrology, seismic considerations, vegetation, details on the typical soil profile characterising the site, the location of the testpits and details on the site investigation.

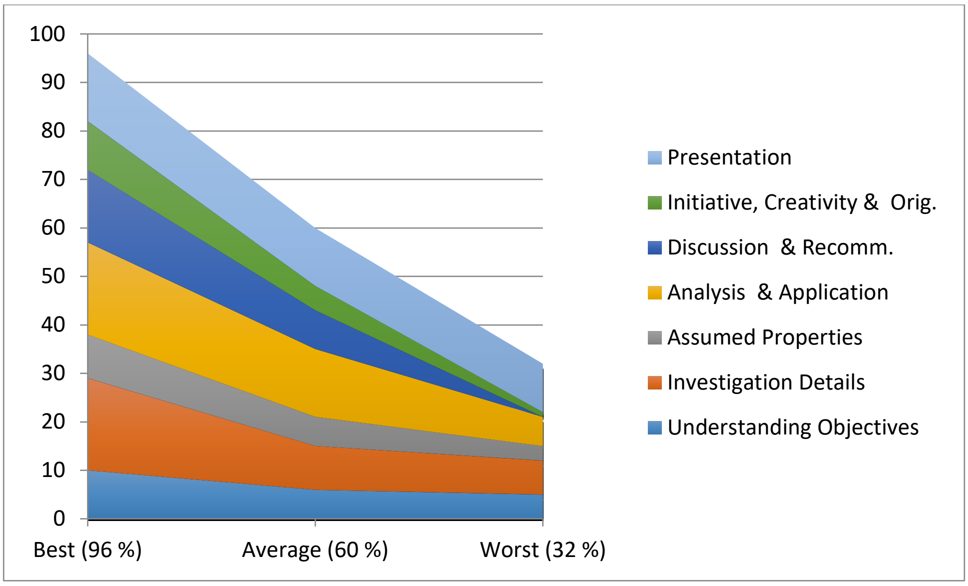


**Figure 4. Cumulative marks obtained for specific assessment criteria of reports**

- The number of testpits and data points collected were in compliance with the SAICE (2010) Site Investigation Code of Practice and GFSH-2 (2002) Specification, for the area size assigned to the group.
- The site investigation included field and laboratory tests or requirements that were relevant to the soil profile allocated to the group. For example, trenches were excavated (rather than deep auger holes), as the soil depth to be investigated (including profiling) was approximately only 3m deep. In addition, with regards to laboratory tests, an undisturbed sample was taken from each layer for the determination of its grading, Atterberg limits and consolidation properties.
- The properties assumed for the tests for the soil horizons were appropriate and reasonable and their source justified, including from previous reports and a journal publication. For example, Elastic Modulus values (from a report) and e vs log pressure relationships (from a journal publication) were assumed to be applicable to the soil profile and hence were used to estimate the settlement.
- The potential problems associated with the different layers were identified (in this case, heave, settlement and bearing capacity).
- The calculations for heave, settlement and bearing capacity were appropriate and correct.
- Spreadsheets were set up for calculating allowable bearing capacity (according to Meyerhof's method) and settlement.
- The Residential Site Class Designation and associated founding recommendations (according to the NHBRC Manual) were correct.
- The group used Google Maps to ascertain the topography and land usage of the area.
- The report was concise, being only 5 pages (excluding the appendices).
- The references were sufficient.

This report indicated that the group understood the objectives of the project. In addition, it was clear that the work covered during the lectures in the various sections including site investigation, bearing capacity, settlement, heave, site classification was well understood and appropriately applied for the development type (single-storey housing), soil profile and area size allocated to the group.

### 5.1.2 Worst report

This report was unacceptable and obtained a mark of 23 %, for reasons that include the following.

- The report appeared to be essentially plagiarised from another geotechnical engineering report which was written for a power station (not a housing development).
- The geology did not correspond with that indicated on the allocated soil profile.
- The minimum site investigation data points specified were excessively incorrect.
- Incorrect layer depths were used in the calculations.
- Bearing capacity, heave and settlement calculations were incorrect.
- The Residential Site Class Designation was incorrect.
- The foundation recommendations were not even relevant to the soil profile allocated to the group. As is evident from Figures 3 and 4, a zero was obtained for the discussion and recommendation aspect of the report.
- The report addressed matters not relating to the housing development.

This report indicated that the objective of the project was not achieved. Furthermore, at no stage did any members of this group utilise the scheduled consultation opportunities, which were available throughout the semester.

## 5.2 Comments

Challenges included a conflict that arose between a group member and the group co-ordinator. This arose as the co-ordinator apparently excluded the member from meetings. The problem was resolved by meeting with both parties.

In addition to the group members of the abovementioned (worst) report, another group failed with a mark of 42 %. The general reasons for this report not meeting the outcomes were as follows.

- The site investigation details were incorrect as they did not comply with the relevant national manuals.
- Bearing capacity calculations were not carried out.
- Incorrect assessment of potential soil problems associated with the allocated soil profile.
- Contradictory inadequate founding recommendations.
- Poor report structure (including the absence of sections and appendices referred to in the report).
- Evidence of plagiarism.

A different problem arose in that one person did not work with their group and submitted an apparently plagiarised report on their own. This report was not marked. In addition, in accordance with the study guide, individual submissions were precluded.

# 6 Conclusions

In accordance with ECSA's requirements, the objective of the group project of Foundation Engineering IV was the solution of "real/industrial/applied problems using fundamental principles that underpin current technology". In this case, the appropriate application of the Foundation Engineering IV course content to a housing project development was required. It was clear that the outcomes of the group project were achieved by 21 of the 23 groups. As such the pass rate was 91 %.

Both reports that obtained failure marks contained evidence of plagiarism. Hence, it appears that the reason why these two groups failed is due to obtaining other geotechnical reports with the aim of adapting their contents to suit the scope of the course project. This precluded the achievement of the outcomes of the course project that necessitated the appropriate application of the subject matter in a simulated situation.

A method was established to fairly allocate a mark to each group member. This method appears fair and successful, as there were no students who were dissatisfied with their project mark or the mark awarded to other group members. Finally, this method was approved by the course Moderator.

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# Author's bio

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Professor George C. Fanourakis joined the Department of Civil Engineering Technology at the (now) University of Johannesburg (UJ) over twenty-six years ago, after leaving his employment at Jones and Wagener (Pty) Consulting Engineers. He received the degrees MSc(Eng) from the University of the Witwatersrand and a DTech(Eng) from the UJ. He is a Chartered Civil Engineer and Fellow of the Institution of Civil Engineers (UK). He is a Fellow of the South African Institution of Civil Engineering, Honorary Fellow and Past President of the Institute of Professional Engineering Technologists, Member of the Soil Science Society of Southern Africa and Member of the fib (Fédération Internationale du Béton). His professional involvement includes serving on three Geotechnical National Standards (SABS) Committees as well as Membership of Commission 9: Dissemination of Knowledge, of the fib. His primary general teaching and research interest areas are Geotechnical Engineering and Concrete Technology. In addition, Prof. Fanourakis is active in research in engineering education.