

A Corpus-Based Approach

to Civil Engineering Nominal Compounding

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• المخلص

- إن هذا البحث عبارة عن دراسة استكشافية لما تتضمنه النصوص العلمية لثلاث فروع لتخصص الهندسة المدنية من تراكيب مختلفة للكلمات الانجليزية المركبة . و يرمي هذا الاستقصاء لتسليط الضوء على هذه التراكيب لتمكين طلبة التخصص من فهمها خاصة و النصوص التي تحتويها عامة. هذا و يبقى الهدف الاسمي هو اعداد مصنف للألفاظ التقنية للهندسة المدنية. من اجل هذا تم اعتماد مقارنة مدونة النصوص من خلال استعمال برنامج وورد سميث لإنشاء قوائم للألفاظ حسب درجة التكرار. و لقد تمخض عن هذا البحث استنتاج التراكيب اللفظية المتنوعة التي تتضمنها النصوص المدروسة و التي يأتي على راسها المركبين المتكونين من اسمين على التوالي او من صفة و اسم على عادة اللغة الانجليزية.
- **الكلمات المفتاحية:** الاسماء المركبة، الانجليزية بالأهداف، المقارنة بمدونة نصوص، الهندسة المدنية.

Abstract

This paper investigates the various types of compounds used in three branches of civil engineering. The aim is to provide field related learners with a clear insight into this discourse element, and hence, enable them to deal with authentic material. Thus, this research is a cornerstone of a long term objective which is "a Civil Engineering Glossary of Terms". As it was opted for a corpus base approach, Wordsmith, a software program, was used to elaborate a vocabulary list on the basis of frequency of occurrence. Conclusively, it has been found that the structure of noun + noun as well as adjective + noun seem to be overwhelmingly predominant.

Keywords: Compound nouns; English for specific purposes; corpus based approach; civil engineering.

Introduction

The technical aspect of civil engineering texts renders its terminology not only difficult to understand but also very complex for second and foreign language learners. In fact, this is due, on the one hand, to the differences between general English and technical English repertoire. And, on the other hand, the high frequency of multi-word combinations makes the comprehension task awkward if not impossible for those who are unfamiliar with English word combinations. Compound nouns vary in terms of word-number (two, three, even four-word combinations are highly attested) and structure, too. Consequently, this put the mastery of civil engineering English terminology in a high priority for the learners of this field.

Linguistic corpus studies have gained ground in the field of (LSP) language for specific purposes in general, and (ESP) English for specific purposes in particular especially in the 1980's (McEnery & Xiao, 2011, chapter 22)¹. Despite its blurred existence in the ESP literature during the early days of its emergence, the use of corpora has proven its effectiveness and wide usefulness as a technical tool in course design. Among the factors which facilitate the use of corpora in the field of ESP is the immense development in computing and technology. Therefore, a huge amount of documents, video recordings, etc. have been made available, accessible and easy to analyse and study.

This paper investigates the different types of word combinations attested in Civil Engineering texts. For this reason, three different books (pdf format) were chosen with regard to the branches taught at Adrar University: Geotechnics, Construction Materials, and Civil Engineering Structures. 54.000, 134.000, and 55.000 Are the number of tokens (the number of running words) for each document. The analysis of the result allows us to classify the different types with regard to their frequency of usage as well as the number of words for each kind of structure and for each branch.

1. Literature Review

1.1 English Nominal Compounding

The main focus of this research is the use of nominal compounding in scientific and technical texts, especially civil engineering writings. Despite the fact that there is a great deal of agreement over the complexity of this area in English language learning for

¹Tony McEnery, and Richard Xiao.(2011).What Corpora Can Offer in Language Teaching and Learning.In Eli Hinkel (Ed.), Handbook of Research in Second Language Teaching and Learning.(pp. 364 -380) Taylor & Francis e-Library.

non-native speakers, a remarkable division among writers is also noticeable over the classification of compound nouns (Bauer, 1998)². Some see this grammatical category as composed of two groups: compound nouns and noun phrases (Quirk & Greenbaum, 1976)³ whereas others consider them as a single category (Bauer, 1998)⁴. Thus, there is not an overall agreement over the criteria which distinguish a compound from a simple free phrase. Some scholars use accentuation, others use spelling; whereas, there is a third group which uses testing as a tool to define compounds (Adams, 1987)⁵. Another issue associated with the technical terms is what criteria should be used to define a technical term from a non-technical one (Bowker & Pearson, 2002)⁶. In this paper, nominal compounds were determined on the basis of two criteria: frequency of occurrence and being technically related.

1.2 Definition

Some see a compound as a word, lexeme, that consists of two elements, the first of which is either a root, a word or a phrase, the second of which is either a root or a word (Plag, 2002)⁷. Yet, throughout this paper this term is confined only to the combination of two grammatical words.

1.3 Characteristics of compounds

English noun compounding has several common features among them are the following ones:

1.3.1 Binary Fragmentation

Actually, English noun compounding can generate a great number of compositions of more than two-word forms. Yet, the majority can be analysed as hierarchical structures of binary (i.e. two-member) sub-elements, in other terms they can

²Laurie Bauer, When Is a Sequence of Two Nouns a Compound in English? *English Language and Linguistics*, 2(1), 1998, p: 65

³Randolph Quirk, Sidney Greenbaum, A University Grammar of English (The Fifth Edition), Longman, 1976, p:444

⁴Opcit, p:65

⁵Valerie Adams, An Introduction to Modern English Word Formation. Longman Group, 1987, p:57

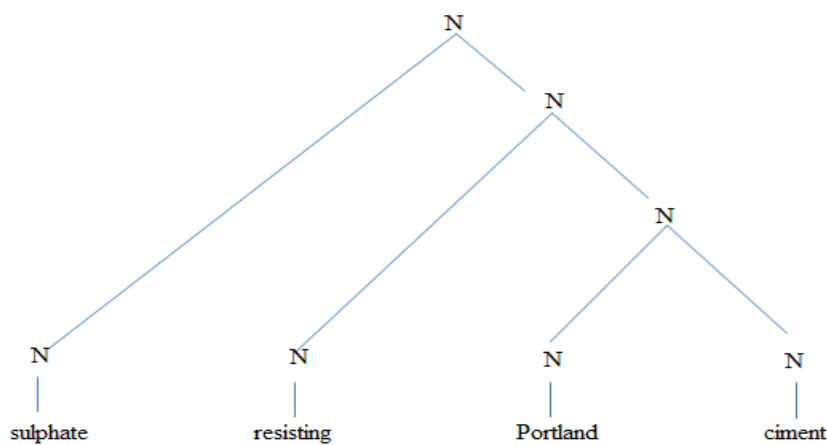
⁶Lynne Bowker, Jennifer Pearson, Working with Specialized Language. Taylor & Francis e-Library, 2002, p:145

⁷Ingo Plag, Word-formation in English. Cambridge University Press Series, 2002, p:173

be divided into fragments of two words (Plag, 2002)⁸. For example the four member compound *sulphate resisting Portland cement* could be analysed as follows, using the bracketing and tree representations.

a. [sulphate [resisting [Portland cement]]

b.



You gotta give it a title this figure

The rules of compound formation can repeat the same kind of structure several times to construct new words. This feature is called **recursivity**(Plag, 2002)⁹.

1.3.2 The notion of head

The left-hand member of a compound noun often modifies the right-hand element. This last, the right hand element, is referred to as **the head** which is modified by the other member of the compound. Such compositions exhibit what is called a **modifier-head structure**(Plag, 2002)¹⁰. For instance consider the word "pressure coefficient". The word

⁸Opcit, p:171

⁹ Ibid, p:172

¹⁰ Ibid, p:194

"pressure" modifies the word "coefficient" i.e. the head. Thus, it can be interpreted as the coefficient of pressure. Semantically, this means that there is a set of "coefficients", in which "pressure coefficient" is one subset (Swan, 2009)¹¹.

1.3.3 Right-hand occurrence

The head in English noun compounding always occurs on the right hand side. This systematic feature is named by William the right-hand head rule (Plag, 2002)¹².

1.3.4 Semantic and Syntactic Features

With regard to their features, compounds obtain their semantic and syntactic characteristics from their heads whatever they are verbs, count noun, or feminine gender. Another feature related to the head is that the plural marking occurs on the head if the compound is pluralized. The inheritance of characteristics from the head is called **percolation**(Plag, 2002)¹³. Nominal Compounding with a head are referred to as **endocentric compounds**.

1.3.5 Lexical Density

The process of forming compounds entails compacting longer sentences and omitting some components which are considered superfluous (such as verbs or prepositions). This tendency towards compacting the lexicon leads to the increase of what is called, in corpus linguistics, the lexical density i.e. the number of lexical nouns in a text¹⁴. Discourse analysts argue that the lexical density of technical academic writings is higher than that of conversations, yet newspaper writings score the highest one¹⁵.

¹¹Michael Swan, *Practical English Usage* (Third Edition). Oxford University Press, 2009, p:358

¹²Opcit, p:173

¹³Opcit, p:174

¹⁴Concepción Orna-Montesinos, *Constructing Professional Discourse : A Multiperspective Approach to Domain-Specific Discourses*. Cambridge Scholars Publishing, 2012, p: 20, 21

¹⁵Ibid, p:21

1.3.6 Compounds Classification

Valerie Adams (1987), in her book *An Introduction to Modern English Word Formation* stated more than 80 categories of compound nouns divided into 11 groups¹⁶. She classified them according to the grammatical structure (subject – verb and verb – object), grammatical class (adjective-noun), and in some cases according to the meaning. As a result, this made some groups overlap with each other, and some categories fell into several groups. In this regard, it was opted for grammatical classification to facilitate compound analysis.

01	Subject- Verb	07	Resemblance
02	Verb – Object	08	Composition / Form / Contents
03	Appositional	09	Adjective - Noun
04	Associative	10	Names
05	Instrumental	11	Others
06	Locative		

Table 1 : Compounds Classification according to Valerie Adams (1987)

1.4 How to Identify Technical Vocabulary

Within the field of ESP, several methods of identifying vocabulary were used. Schmitt (2010) cited two main ways¹⁷, whereas Coxhead (2013) added a third one to the other approaches¹⁸.

1.4.1 Consulting experts and technical dictionaries to identify specialized vocabulary

Field related experts are sometimes consulted in identifying specialized vocabulary so that to help determine technical terms (Cabr , 1999)¹⁹. Several drawbacks of this approach are classified by Schmitt. For instance, he argues that several experts on the

¹⁶Opcit, p: 61

¹⁷Ibid, p:77.

¹⁸Ibid, p:77.

¹⁹Mar a Teresa Cabr , *Terminology: Theory, methods and applications*. John Benjamins Publishing Company, 1999, p:132

same topic might come up with quite different lists due to the differences in terms of their background knowledge, the systematicity of the approach used, and the difficulty of the technical word itself (2010)²⁰. According to him, technical dictionaries may have been produced through this method; however, they have been also used to help determine specialized terms (Schmitt, 2010)²¹.

1.4.2 Using a scale to identify specialized vocabulary

A four-step scale to categorise technical vocabulary was established by Chung and Nation (2003)²². Step one is dedicated to identify words that have no specific connection to a subject matter. Step two on the scale embraces words which are minimally related to the subject matter. Step three is concerned with the words that are more closely related to the subject area. Step four contains only closely related terms to the technical subject matter.

1.4.3 Corpus-based studies to identify specialized vocabulary

Another approach to identifying specialized vocabulary is based on corpus studies. Word frequency lists produced in the corpus based approach are particularly helpful as they determine words in context. Crawford Camiciottoli (2007) provides an example of using a corpus - linguistic approach to classify specialized vocabulary²³.

1.5 Conclusion

Throughout this paper a combination of two methods was used to identify technical vocabulary. The first method is producing word frequency lists i.e. a corpus based approach, the second method is consulting experts. Thus, this would help crosscheck the result and hence produce reliable vocabulary lists.

2. Research Methodology

²⁰Opcit, p: 77

²¹Opcit, p:77.

²²Chung, T. M., & Nation, P. , Technical vocabulary in specialised texts. *Reading in a Foreign Language*, 15(2), 2003, p:103-116.

²³Belinda Crawford Camiciottoli, *The Language of Business Studies Lectures: A corpus-assisted analysis*. John Benjamins Publishing Company, 2007, p:31,43

Software data processing tools have facilitated corpora analysis remarkably especially with the development of the web network which eases the access to authentic language material. As a matter of fact, the extensive use of computer and technology has made the empirical results highly accurate and the data easily manipulated in several ways (Bowker & Pearson, 2002)²⁴.

The present paper tackles the use of compounds in civil engineering field. Therefore, three field-related fundamental documents or books were chosen with regard to the branches taught at Adrar University. The total number of running words (tokens) in the whole corpus is 244.827 tokens; the first document , entitled Construction Materials (Domone & Illston, 2010), consists of 134.728 tokens²⁵; the second book called Principles of Geotechnical Engineering (DAS, 2010), contains 54.844 tokens²⁶. Whereas, the last one, Fundamentals of Structural Engineering (Connor & Faraji, 2012) embraces 55.255 tokens²⁷.

The aforementioned documents were chosen on the basis of several considerations related to the size, type of texts, online availability, etc. (Orna-Montesinos, 2012)²⁸. The documents chosen are basically field related i.e. each one of them can be considered as a fundamental reference in its domain and, hence, it contains a wide range of information, concepts, and consequently a wide variety of technical terms. However, it would not be the case if research articles were chosen instead.

The authors of those documents are English native speakers; which means that the issue of authenticity of material is secured in this way. And hence, the linguistic features defined would be reliable to some extent.

As for the size of the corpus, more than 240.000 tokens is quite a considerable number. Despite this, some argue that a big size does not necessarily mean a good corpora (Bowker & Pearson, 2002)²⁹. Yet, in the present case, all of the documents chosen consist

²⁴Opcit, p:9,10.

²⁵Peter Domone&John Illston(Eds.), *Construction Materials* (Fourth edition),Spon Press, 2010.

²⁶BRAJA M. DAS, *Principles of Geotechnical Engineering* (Seventh Ed). Cengage Learning, 2010.

²⁷Jerome J. Connor, &Susan Faraji, *Fundamentals of Structural Engineering*, Springer, 2012.

²⁸Opcit, p:17

²⁹Opcit,p: 45

of several sub-parts and chapters, each of which deals with a given aspect of the main domain.

Concerning the issue of copyright and permissions, the electronic documents used were extracted from the internet, i.e. they are open access via SNDL Cerist.

Since the use of software program processing tools requires the electronic documents to be in a plain text format (*.txt), we converted them to pdf files. In the meantime, all the photos, graphs, diagrams and unnecessary parts were removed; only the core texts and headings were left in order to get accurate statistical data. Furthermore, it was necessary to check the final document for any possible mistake.

Despite the fact that there is an important number of software programs processing tools it was opted for using Wordsmith 4 (a free version) for several reasons. Firstly, it has been used for over thirty years and since its invention has been enhanced for several times (three times). Secondly, it is widely used in linguistic academic research and acknowledged by recognized universities. Thirdly Wordsmith has some unique options which other programs do not have.

The investigation process combines between the computer analysis and the manual study because some grammatical, semantic and linguistic features are not recognized by the software program.

The words are classified according to the number of components (2 words, 03 words, 04 words, and 05 words) and refined by eliminating collocations which contain function words (articles, pronouns, etc.). Then, the word class of each constituent was determined to elaborate lists with regard to the grammatical structure, for example, NN = Noun + Noun or Aj N= Adjective + Noun, etc.. The most frequent types of structure were analysed and then prepared to be used as language material for a civil engineering course.

3. Data Analysis

Several stages were followed to classify and study the data, and each stage contains a number of steps.

3.1 Token, Words, and Type Numbers

	book's title	tokens	words	types
01	Fundamentals of Structural Engineering	55255	3127	1581
02	Principles of Geotechnical Engineering	54844	4247	2540
03	Construction Materials	134728	10165	5049

Table 2 : Tokens, Words, and Types Numbers

The three documents chosen were respectively entitled Fundamentals of Structural Engineering, Principles of Geotechnical Engineering, and Construction Materials their Nature and Behaviour. Despite the fact that they vary in size (number of tokens, words, and types), the number of tokens is always the highest (the linguistic elements all encompassed); the frequencies of words are lesser than those of tokens and higher than the frequencies of types, the term word in this regard refers to one single form of a linguistic unit, where the term type refers to a group of words derived from one single root. For instance, the type of the word " vary" has five forms i.e. **words**: vary, varies, variety, varieties, varying, and various, and a total number of 350 tokens (the total number of running words).

3.2 The Number of Compound Nouns per document

Compounds were classified firstly with regard to the number of their constituents and secondly according to the word class of those constituents.

3.2.1 Nominal Compounding Configuration Regarding Constituent-number

	book's title	02 words	03 words	04 words	05 words
01	Fundamentals of Structural Engineering	313	94	16	02
02	Principles of Geotechnical Engineering	294	119	40	01
03	Construction Materials	689	84	11	06

Table 3: Nominal Compounding Configuration Regarding Constituent-number

Obviously, in all of the three documents, two-word compounds have the highest frequency of occurrence followed by three-word compositions, then four, and five-element compounds have the lowest rate of occurrence. This is quite logical because English binary compounds are the fundamental composition from which all other compositions can be generated (Plag, 2002)³⁰.

3.2.2 Classification of Compounds According to the Word Class of their Constituents

³⁰Opcit, p:172

	book's title	Type of structure			
		02 words	03 words	04 words	05 words
01	Fundamentals of Structural Engineering	07	18	11	02
02	Principles of Geotechnical Engineering	06	18	13	01
03	Construction Materials	08	15	08	05

Table 4: Number of Nominal Compounding Types of structures

The analysis of compound nouns classified previously unveils that there is a multitude of types of structures that vary remarkably in terms of structure and number of components. Three-word composition varies greatly in grammatical structures compared to other word compositions. Yet, since all of them acknowledge the binary structure, only two-word types are to be analysed later on.

3.3 The Types of Binary Nominal Compound Structures

The thorough analysis of nominal compounding configurations shows that almost the same kinds of structures display throughout all the texts and documents. The sole difference is that the structure verb + noun is unique for one document "Construction Materials" and the structure Ved + Ving was not attested in another document "Principal of Geotechnical Engineering".

	Fundamental of Structural Engineering	Construction Materials	Principal of Geotechnical Engineering
1	Adjective Noun	Adjective Noun	Adjective Noun
2	Adjective Ving	Adjective Ving	Adjective Ving
3	Noun Noun	Noun Noun	Noun Noun
4	Noun Ving	Noun Ving	Noun Ving
5	VedVing ³¹	VedVing	Ved Noun
6	Ved Noun	Ved Noun	Ving Noun
7	Ving Noun	Ving Noun	
8		Verb Noun	

Table 5: The Types of Binary Nominal Compounding Structures

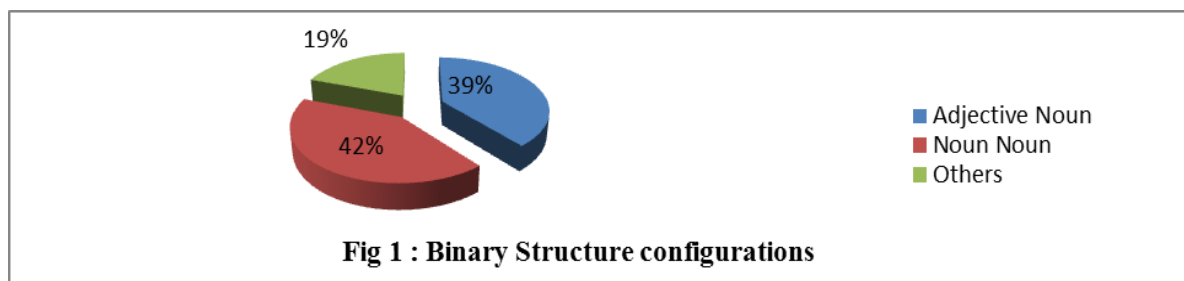
3.4 Frequency of Usage of Binary Structures

³¹**NB:** *Ved* refers to the past participle of a verb whereas *Ving* is itsing form

		Noun Noun	Adjective Noun	Other
01	Fundamentals of Structural Engineering	130	122	61
02	Principles of Geotechnical Engineering	144	116	34
03	Construction Materials	346	253	90
	The total	491	620	185

Table 6: Frequency of Usage of Binary Structures

Despite the rich variety of binary structures, only two types seem to be the most predominant kinds of structures in the three documents (Noun + Noun 42 % and Adjective + Noun 39 %). This finding goes along with recent trend of research which has privileged the analysis of the aforementioned types of structures and neglected the others (Sergio Scalise & Antonietta Bisetto, 2015)³².



3.5 Example of Noun + Noun Combination: blast furnace

Concordancing tool displays words in their textual context. This option facilitates the analysis of the internal organization of words with regard to their contextual linguistic system.

N°	Lexeme	Count / Uncount	Sing / Plural	Nbr of com p	Structure	Frequency
01	Blast furnace	C	S	2	N + N	4
02	Blast furnace slag	U	S	3	N + N + N	4
03	Blast furnace cement	U	S	3	N + N + N	1
04	Blast furnace slag cement	U	S	4	N + N + N + N	1
05	Portland Blast furnace slag cement	U	S	5	N + N + N + N	1
06	Ground blast furnace slag	U	S	4	N + N + N + N	1

³²As cited in Lieber, Rochelle, and PavolŠtekauer, eds. *The Oxford Handbook of Compounding*. P: 49,82., 2015. Web.

07	Ground granulated blast furnace slag	U	S	5	N + N + N + N + N	7
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Table 7: Compound derived from the lexeme "blast furnace"

The concordance of the lexeme "blast furnace" demonstrates that there are six compound nouns generated from this noun; they vary in constituent number and in meanings. This might help understand their meaning from the context, learn how to produce new lexemes, and even how to use them. The longest one "Ground granulated blast furnace slag" seems to be more important as it is squeezed in an acronym "GGBS".

3.6 Example of Adjective + Noun Combination: critical stress

N	Concordance
1	to remove unwanted particles • ground granulated blast furnace slag (GGBS), which requires energy for
2	contaminated soil, waste from road cleaning, coal ash, blast furnace slag and municipal solid waste incinerator ash
3	which involves the two stages of reduction to pig iron in a blast furnace followed by conversion to steel, both of which
4	and calcium– sulphoaluminate cements, blast-furnace slag cements and phosphate cements
5	rock. The main non- natural aggregate source is slag, with blast furnace slag being the most commonly used. As with
6	criteria BS EN 15167-1:2006 Ground granulated blast furnace slag for use in concrete, mortar and grout.
7	by the incorporation of fly ash or ground granulated blast furnace slag. We shall discuss the effect of transient
8	the use of additions; fly ash or ground granulated blast furnace slag (ggbs) are effective solutions, as shown
9	material which, it is claimed, will outperform blast furnace slag when used as an addition to Portland
10	are blended with an alkali-silicate activator and ground blast furnace slag the resulting cement has accelerated
11	components include: • slags such as ground granulated blast furnace slag, granulated phosphorus slag, steel slag
12	cement: Portland cement with 35–80% of a mixture of blast furnace slag with natural or calcined pozzolan or fly
13	or with up 35% of a mixture of these additions • CEM III Blast furnace cement: Portland cement with 35–95% ggbs
14	years blends with ggbs have been known as Portland Blast Furnace cements and blends with fly ash Portland
15	particle density Particle shape ggbs, ground granulated blast furnace slag. Notes: • Most but not all specific
16	(ggbs) – slag from the 'scum' formed in iron smelting in a blast furnace , which is rapidly cooled in water and ground
17	particle size range for use in concrete • ground granulated blast furnace slag (ggbs) – slag from the 'scum' formed in
18	About three or four times as much molten metal from the blast furnace is then poured in using a ladle. The furnace is
19	haematite (Fe2O3). The iron oxide is reduced to iron in a blast furnace , which is a large steel vessel up to 30 m high

Figure 1 : Extract from the concordance for 'blast furnace'

In addition to the grammatical information, the analysis of the noun "critical stress" in context tells us more about the technical features of this term. In other words, the context defines this term by saying that "critical stress" has level, values, intensity, and this last "intensity" has also a factor.

N	Concordance
1	a material can then be represented by a critical stress intensity factor, K_{Ic} , and
2	threw doubt on the existence of a critical stress level below which creep
3	For crack propagation to occur, the critical stress intensity at the crack tip
4	to behave according to LEFM, i.e. its critical stress intensity factor (or fracture
5	Figure 40.8 shows schematically the critical stress values in the principal
6	(or distortion) system. Fig. 40.8 Critical stress values in the principal
7	factor (K) that is much less than the critical stress intensity factor K_c (see
8	many dislocations can pile up and the critical stress is reached early, whereas
9	fracture the value of K is called the critical stress intensity factor, K_c . K_c is

Figure 3: Extract from the concordance for 'critical stress'

N°	Lexeme	Countable / Uncountable	Sing / Plural	Nbr of comp.	Structure	Frequency
01	Critical stress	U	S	2	Adj + N	1
02	Critical stress level	C	S	3	Adj + N + N	1
03	Critical stress values	C	Pl	3	Adj + N + N	2
04	Critical stress intensity	U	S	3	Adj + N + N	1
05	Critical stress intensity factor	C	S	4	Adj + N + N + N	4

Table 8 : Compounds derived from the lexeme "critical stress"

Conclusion

The study of nominal compounding technical texts related to three branches of civil engineering, Geotechnics, Construction Materials, and Structure on the basis of the corpus approach has consolidated some previous findings, unveiled new findings, and offered handy teaching materials.

The processing and compilation of a corpus of more than 244 827 tokens comes up with:

- 09 five-word compound nouns
- 67 four-word compound nouns

- 297 three-word compound nouns

- All of them are derived from 1296 binary-structure compound nouns. These last are divided into eight types of configurations; however, two types are overwhelmingly predominant (noun + noun and adjective + noun)(Lieber & Štekauer, 2015)³³

This corpus can, on one hand, constitute a starting point for an ongoing project of a civil engineering glossary of terms. And, on the other hand, it is a useful teaching material since:

- it covers all the disciplines of civil engineering taught at Adrar university.

- it displays technical terms in their genuine context.

- it offers several examples of usage of each term (depends on the frequency of occurrence)

- it helps understand how more complex compounds are generated from binary structures.

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