Morphological Characteristics of the Language used in Civil Engineering

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Abstract
This paper aims at investigating the particular features of civil engineering written discourse. A first assumption is made that the language employed in civil engineering is a subcategory of English for Specific Purposes. As part of ESP, it is thus bound to have a set of specialized lexical and grammatical features which are not in the repertoire of the non-users of that particular domain: complex noun phrases, special use of articles, special use of modal verbs, frequency of the passive voice and of present tense simple, long complex sentences, collocations, specialized terminology. Focus will be laid on demonstrating that the morphological features mentioned above are present in the texts which were selected for analysis. The texts belong to different domains related to civil engineering, namely steel structures, concrete constructions, building materials and railway systems. Two main morphological categories will be analysed in detail, i.e. the noun and the verb. In the part referring to the nominal component, the noun phrases used in the corpus, the special use of the articles and a process which we consider typical for our type of discourse, i.e. nominalization, will be investigated. In the section focusing on the verb, the voice, tense, aspect and the values of the modal verbs used in civil engineering texts will be analysed.

Key words: civil engineering, morphology, noun phrase, nominalisation, passive voice

Introduction

As part of ESP, the language use in civil engineering has a set of 'specialized' grammatical features which are not in the repertoire of the non-users of that particular domain: complex noun phrases, special use of articles, special use of modal verbs, and the frequent use of the passive voice.

This paper is an attempt at assessing the morphological characteristics which ESP shares with the civil engineering texts that we selected as the corpus to be investigated. The texts selected for this analysis include a course book intended for academic use, two books

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from different fields, articles regarding the use of specific machinery and two Eurocodes.

The first part of our study lays focus on the noun, special attention being paid to the high number of noun phrases, the smaller amount of uncountable nouns, the special use of the articles and nominalization, a process which we consider typical for our type of discourse, whereas the second one focuses on the verb. A quantitative assessment of the total number of verbs present in our corpus will be given, and comparisons will be drawn with the total number of the other important morphological categories. An analysis of the relevant aspects of such verb categories as voice, tense and aspect employed in civil engineering texts, as well as of the specific aspects of modality will also be made.

1. Distribution of Morphological categories

> It was important to construe a world of 'things', including virtual entities that could be brought into existence as and when the discourse required them; some of these virtual entities then remain in existence as theoretical constructs, while others function locally in the argument and then disappear. Symbolically, this kind of discourse is holding the world still, making it noun-like (stable in time) while it is observed, experimented with, measured and reasoned about. (Halliday 2004:21)

Considering the specificity of civil engineering texts, namely the factual, informative purpose, the description provided by Halliday could be very well applied to our texts. The quantitative assessment was extended to all the relevant morphological categories (nouns, verbs, adjectives and pronouns) and the percentages for each of them were calculated.

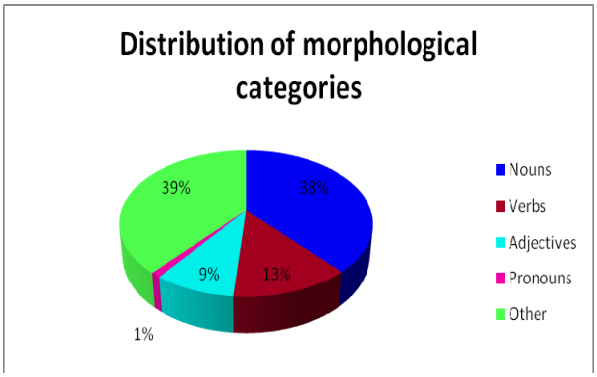

Fig. 1 – Percentage of morphological categories

As apparent from the pie chart above, the percentage of verbs used in our corpus is less than half of that represented by nouns (13% verbs, compared to 38% nouns). This only comes as a confirmation of all written above and further supports our statement that the use of fewer verbal compounds as compared to the nominal ones adds to the informative purpose of these texts, which will be further argued.

2. The Noun

2.1. Nominalization

Nominalization, a procedure describing a situation in which "a process, congruently construed as a verb, is reconstrued metaphorically as a noun" (Halliday, 2004: 107), is considered by Widdowson, following Stubbs, to be a means to allow "other information to be omitted, since a noun phrase does not mark tense" (Widdowson, 2004: 124). Paltridge and Starfield (2013) consider nominalization, along with passivisation a procedure through which we can obscure processes and actors. It is also a feature represented in our corpus, sometimes precisely because of the lack of agentivity.

Thus, in *Strength of Materials* "the study" is frequently mentioned (around 10 times). One of our findings was that *neglection*, *a cut in the bar*, *the intersection of planes* (several times), *from the examination*, *computations and reductions*, *the determination of stresses* (more frequently used than the corresponding verb), *elongation* and *deformation* are always used, while the corresponding verb is never employed.

In *Design Procedures for Sidewalls of Socket Foundation*, the author describes the *transmission of the forces*, the *analysis* used for *investigation* (the verb *to analyse* occurs eight times vs. the 20 occurrences of the corresponding noun), *the interaction between shear and bending*. On the other hand, the verb *to load* (15 entries) is much more frequently used that the noun *loading* (6 entries). *Implementation*, *application*, *computation* and *interpolation* are other examples where the author showed a preference for nominalization.

Examples of nominalization are also found in "Design of Hydraulic Gates". We can mention *operation*, *sealing* or *seals* (in the case of these nouns, the verbal counterpart is never employed), *gates […] intended for use*, *movement of the gate*, *opening or closure*, *maintenance and repair*, *construction*, t*ransportation* (this one also very often), *complete installation or removal*, *the gate placement*, *the water passage*.

After analysing the examples listed above, we concur with Paltridge & Starfield in that nominalization in civil engineering discourse allows "complex information to be compressed into a word. And it also allows a high level of abstraction" (2013: 165). Another important function of nominalization which the two authors mentioned is that it allows the progress of the argument by expressing a process in a clause, while in the next one the same process becomes nominalized. Thus, in one of the texts, reference is made to a force that is "transmitted", followed by the "transmission of the force".

2.2. Noun Phrases

We analysed the amount of nouns and noun combinations found in our corpus. We decided to split the noun phrase into two categories: noun phrases containing an "of" phrase as modifier and those without a prepositional phrase modifier. The prepositional phrases, the "OF" phrases are a category of NPs which abound throughout all the texts.

There is also an important number of very heavy noun phrases, some with more than one "of" modifier, where "the nominal group expands lexically, by […] modification: one noun functions as a kind of keyword, and other words are organized around it, having different functions with respect to this head noun." (Halliday, 2004:62). Following Halliday's line of thought, this type of noun phrase offers the possibility of organising an important quantity of lexical information into functional items. The role of these noun phrases is to "construe participants - entities that participate in processes; these are the more stable elements on the experiential scene, which tend to persist through time whereas the processes themselves are evanescent." (idem: 63). In other words, "meaning in science tends to be expressed nominally rather than causally" (Paltridge & Starfield 2013: 171). Groups of noun phrases selected from all the texts under analysis are given below.

Noun phrases related to Strength of Materials:
Strength of Materials, the width of the section, the plane state of stress, theory of elasticity, components of the stresses, the ensemble of four components of the stresses, the stress tensor of the plane state of stress, the methods of the Theory of Elasticity, the system of coordinate axes, the sum of the normal stresses, the discussion of the root of this equation, the equation of a circle having the radius […];
Noun phrases related to Design Procedures for Sidewalls of Socket Foundation:

the side wall of the socket, tie model for the design of the side wall, a system of side walls called socket, the pressure of the column, the design of shallow foundations, the moment capacity of the column, the value of the shear force in the column, the design of the side walls of the socket, the thickness of the side wall, state of stresses, the characteristic compression strength of the concrete, the angle of the strut;

Noun phrases related to Mechanical splices of reinforcing bars:
the integrity of reinforced concrete, a particular method of construction, the specified yield strength of the bar, Three types of compression splices, the deformations of the rebar, the internal ribs of the sleeve, lack of heat resistance, the walls of the sleeve;

Noun phrases related to Aggregates for Concrete:
the workability of plastic concrete, the durability, strength, thermal properties, and density of hardened concrete, aggregate properties affecting performance of the concrete, the relation of mass to volume of aggregates in a stockpile or bin, byproducts of an industrial process;

Noun phrases related to Design of Hydraulic Gates:
the sides of the gate leaf, the cylindrical surface of the skin plate lower portion, Protection of the bottom seal, the creation of a low-pressure zone under the overflowing nappe, the construction of air vents with exits at the piers, the stability of the overflowing water nappe, precise regulation of the reservoir level, gradual lowering of the flap gate;

This text exhibited the greatest number of complex "of" noun phrase.
Noun phrases related to Design of concrete structures:
the harmonisation of technical specifications, Design of masonry structures, design of timber structures, Application of design procedures, the determination of thermal and mechanical actions to the structure, Analysis of parts of the structure, requirements for the safety and serviceability of structures, passive methods of fire protection, premature collapse of the structure, Basis of structural design, Steel for the reinforcement of concrete, The temperature of reinforcement at which failure of the member in fire situation, failure of the structure on one side of the wall;

Noun phrases related to Design of steel structures:
Restriction of the lateral or rotational movement, core thickness of steel material, The cross-sections of cold-formed members and profiled sheets, Typical forms of stiffeners for cold-formed members and sheets, the other cross-sectional dimensions of cold-formed members and sheeting, webs of trapezoidal profiled sheets, The developed height of a web, The developed width of a flange;

Noun phrases related to Civil Engineering for Underground Rail Transport:
the potential traffic usage of the route, severity of curvature, The viability of an underground railway, Backfilling and final reinstatement of ground surface, the sequence of construction, diversions of sewers and drains, the transmission of noise and vibration, the construction of the railway;

In the case of highly specialized noun phrases, one of the first findings was that the distribution of these structures across the selected corpus is not uniform, some texts displaying significantly higher percentages of this type of noun phrases than the rest.

Noun combinations and noun phrases containing adjectives are other widespread categories of noun phrases encountered during the analysis.

Having compared the average number of noun phrases encountered in our corpus, we can draw the conclusion that the presence of shorter or longer NPs is typical for civil engineering text. As far as their function in the discourse is concerned, noun phrase repetition is a means of achieving cohesion in a large category of texts (Paltridge & Starfield 2013).

2.3. About (un)countability

Another category on which we have focused is that of countable and uncountable nouns. There are plenty of examples of uncountable nouns in the corpus selected.

hydraulic cement concrete, granular material such as sand, gravel, crushed stone, blast-furnace slag, durability, strength, density, grading, To evaluate consistency, the total dry sample mass, accidental loss due to spillage, the problem of excessive fineness of the aggregate, to minimize drying shrinkage, to avoid evaporation, The bulk specific gravity, surface moisture, nuclear-radiation shielding, aggregate absorption, consistency;

The analysis of the corpus in terms of the countable/uncountable opposition has revealed several important aspects which we consider typical for technical civil engineering texts. We must first mention that there is a clear preference for countable nouns versus the uncountable ones, the percentage of the latter being rather low (less than 7% - see diagram below).

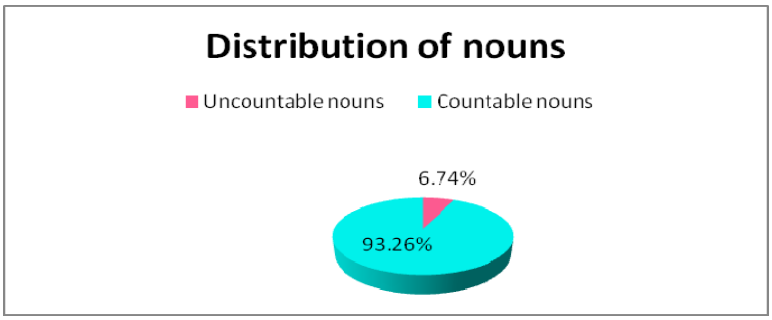

Fig. 2 – Distribution of Nouns

2.4. Special Use of the Definite Article

Louis Trimble (1985: 121) discussed the use of the definite article, with an emphasis on its specialized use: its occurrences in defining (generalizing) statements, whereas a bare plural or an indefinite article should be expected. The second specialised use mentioned by Trimble was the ability of "the" to mark the part described as being unique, independently of whether it is its first occurrence in the text or not.

We studied the use of the definite article in a series of texts in order to investigate such a tendency. The results obtained after the investigation are expected: indeed, the use of the definite article is that described by Trimble and mentioned above. The examples provided below illustrate the two types of usage listed by Trimble.

> […] the induced stresses in cross-sections (in the first paragraph of the introduction), In this case we can imagine that we are cutting **the** bar or **the** beam […] (instructions in a problem), We draw **the** circle of diameter 0B=σ_x+σ_z having t**he** centre […] (description of a model), We shall show that, at the scale of **the** graphic construction […] (description of a model); Then **the** safety will be ensured if […] (description of a theory). **The** bearings are rigidly anchored to the sill and spaced from 2.5 m 104 m. 2.2 CYLINDER GATE **The** cylinder gate has a cylindrical-shaped leaf, which executes a vertical translation movement.

3. The Verb

As visible in the pie chart at the beginning of this article, the verb is the second best represented category in our corpus. Since this feature is valid for all the selected pieces of writing, we can state that civil engineering texts exhibit a nominal structure, since the content is conveyed through nouns and nominal compounds. An explanation for

this preference is offered by Halliday (2004) who calls a noun an entity, a thing, while a verb is a happening. Thus, a nominal group realises **"participants"** (Halliday, 2004: 34), while a verbal group realises **"processes"** (ibid.). By the aid of the numerous nominal constituents occurring in texts, a particular type of discourse typical for sciences is built.

3.1. Tense and Aspect

In civil engineering texts, there is a clear preference for simple present and past tenses, with rare occurrences of the future tense. In support of this statement, plenty of examples can be found in our corpus. Present simple is, however, the tense that prevails: *The ensemble of four components of the stresses defines the stress tensor …, the subscripts of the normal stresses represent the axis …, we notice that these axes are …, This result expresses the following:; proper splicing of rebars becomes essential to the integrity of reinforced concrete., … codes frequently require such long laps …, Splices transfer tension or compression loads from one piece of reinforcement to another, The filler material flows between the bars …, Metal or rubber side seals, attached to the side end plates of the leaf, permit side scaling at all gate positions., Flap gates […] have their maximum height limited to about 5 m; …the total of masses retained differs from the original sample mass., The individual percentage of material between successive sieves is sometimes of interest., Only the effects of thermal deformations […] need be considered., Informative Annex B provides two alternative methods. …the design […] depends on the aspect ratio of the wal., the finite analysis works with a large number of elements.*

Present simple has, in some of the examples we have analysed, what Trimble (1985) called the non-temporal use of tense. This refers to writers not using "time as the major factor governing their choice of verbal tense" (Trimble 1985: 123) when writing a piece of discourse. Thus, the present indicative can show almost any other time except the time now. Trimble specifies that the non-temporal use of tense is dependent of rhetorical factors and lists the following areas where non-temporal use of tense occurs regularly in scientific discourse: "1. when writers describe an apparatus; 2. when they make tense reference to a visual aid; 3. when they refer to previously published discourse related to the subject of their topic." (ibid.) His statements are entirely supported by examples in our corpus: *MCFT is a theory elaborated by Vecchio and Collins ..., MCFT is a smeared crack theory specific for reinforced*

concrete elements which considers that cracks direction is normal to the direction of the principal tension strain (fig. 4). ("Design Procedures for Sidewalls of Socket Foundation"). The first example is an illustration of the first area of non-temporal use of present tense, while the second one illustrates the third area listed by Trimble.

As regards the use of simple past, Paltridge & Starfield (2013), citing Myers, write that in research articles past tense is used for methods and present tense "for well-accepted facts in the discipline." (Paltridge & Starfield 2013: 168) In textbooks, on the other hand, mainly the present tense is used usually due to the fact that they only contain published research which is largely accepted by the research communities involved. The information is therefore presented as facts. The following fragment belonging to a research article proves the aforementioned theory to be true, as it describes a method previously used in another experiment and the tense used is the past:

> Several values were proposed for this parameter. For example, Vecchio and Collins [5] proposed a value of 200 based on their experimental results; Collins and Mitchel [6] proposed a value of 500 for this parameter based on the results on another set of panels, while Benz [7] proposed a more rational formula that depends on the reinforcement ratios in the two orthogonal directions. (from "Design Procedures for Sidewalls of Socket Foundation")

3.2. Voice

Voice is another aspect which we focused on. The approach is again quantitative, since we tried to determine which voice is favoured in our corpus. We calculated the percentage of passive versus active verbs in each of the texts we chose. By active and passive verbs we understand verbal phrases, not each verb individually ("will be taken into consideration", "the width being considered as reduced"). The results are presented below.

> **Strength of Materials**: 48.27% passive, 51.73% active
> **Design of Concrete Structures**: 73.68%, 26.32% active
> **Design of Hydraulic Gates**: 69.89% passive, 30.11% active
> **Mechanical Splices…**: 58.62% passive, 41.38% active
> **Civil Engineering for**…: 42.42% passive, 57.58% active
> **Aggregates for Concrete**: 58.35% passive, 41.65% active
> **Design Procedures**: 51.35% passive, 48.65% active

The results above are very interesting. Six of the eight pieces of discourse chosen for the analysis have more than half of their verb phrases in the passive voice. Several examples are listed below:

The load-bearing function should be maintained during the complete endurance of the fire …, Design values of mechanical (strength and deformation) material properties Xd,fi are defined as follows:, The value of γM,fi for use in a Country may be found in its National Annex., 1) the effects of actions may be obtained from a structural analysis …, Expression (2.4) and different values of the combination factor ψ1,1 are shown in Figure 2.1. Rubber or wood seals are also used., On gates with metal seals, the transmission or the hydrostatic load to the embedded parts is carried out through the seals., The loads are transmitted from the column to the foundation …, The geometry of the strut is determined from the model presented in fig. 2.a., Special attention should be given to cases in which different materials are intended to act compositely, They are commonly used for bars in columns, Since the sleeves are manufactured from materials other than rebar.

Only two texts, i.e. *Strength of Materials* and *Civil Engineering for Underground Rail Transport*, exhibit percentages of passive verb phrases lower that 50%, but the difference is perfectly insignificant.

There is, as shown above, a tendency in civil engineering texts to favour passive rather than active voice, to focus on the action, process, experiment, rather than the actor or agent. This tendency finds part of its explanation in the fact that in some cases, the agent of the action described by the use of passive in unknown, whereas in others it is completely irrelevant to the piece of discourse.

3.3. Modals

Modal verbs are commonly found in technical texts and civil engineering discourse is no exception to this rule. We tried to assess the number of modal verbs employed in our texts, as well as the way they are spread across our corpus. We intended to see if there are modals which occur with greater frequency than others and if this occurs in particular texts or it is a general characteristic. The table below summarizes the results in terms of percentage of the total number of verbs.

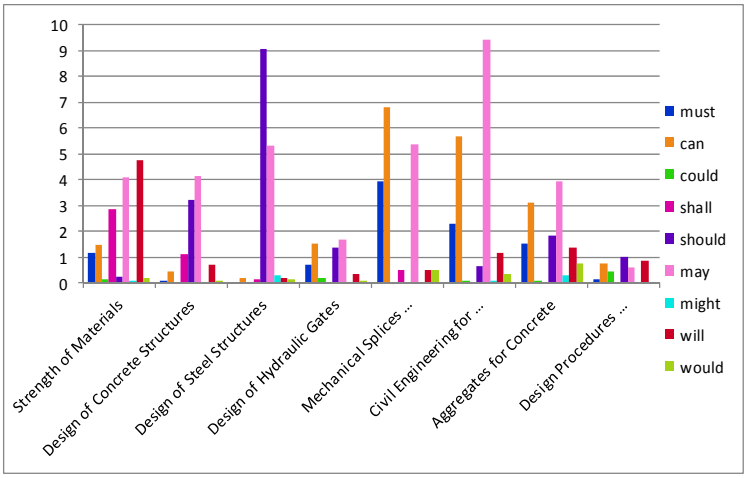

Fig. 3 – Distribution of modal verbs

As can been seen from the chart above, modal verbs do not represent a homogenous class, either in terms of total number or in terms of distribution. It is obvious, in the case of modals, that there is a clear distinction among the use of each verb with respect to certain type of texts. Thus, as the chart shows, the verb *should* is more frequent in eurocodes ("Design of Concrete Structures" and "Design of Steel Structures") and less frequent in the other texts: *the reference to this specific curve should be identified by the letters "HC" …, the element should resist a horizontal concentrated load as specified in EN 1363 Part 2., the average temperature rise of the unexposed side of the construction should be limited to 140 K …, the emissivity related to the concrete surface should be taken as 0,7.*.

This is an instance of the deontic use of modal verbs, when the speaker, or writer in our case, intervenes in a text to express obligation or necessity. (Downing & Locke 1992). The same use of "should" for giving commands or instructions is mentioned in Leech and Svartvik (2003) and emphasised as typical for science and technical discourse by Trimble (1985). This particular use of the modal "should" does not come as a surprise, given the prescriptiveness of these pieces of discourse (norms for design of different structures).

"Can" is another modal highly used throughout our corpus: *bear-trap and flap gates can be hydraulically regulated …, These forces can reach very high values …, the incidence of any cracking can then have a critical influence on corrosion and durability, Hazardous sites and ground conditions*

can be major considerations, a particular method of construction can also make lap splices impractical.

Verbs like "might", "could" or "would" or even "must" are hardly present in any of the texts we selected: *Additionally, the resistance of the strut will also be defined by the mean shear stress, It must be specified that at least four Gauss integration points have to be used …, no greater depth of water than 25 ft. (7.62 m) could be discharged over all ogee spillway….*

As a conclusion, we can say that modal occurrences in civil engineering texts are not homogenous and are determined by the communication needs of the discourse under analysis.

Conclusions

After the detailed analysis and assessment of the morphological features present in civil engineering texts, several conclusions became apparent:

- Civil engineering texts favour heavy noun phrases, with more than one modifier; in most cases a prepositional case functions as modifier. Noun phrases modified by nouns or adjectives are also extremely frequent.
- Civil engineering texts favour the nominal component; this is apparent from the great number of nouns and noun phrases employed in these texts, which are three times more than the number of verbs and verb phrases present in the same corpus.
- The process of nominalization is also present in our corpus, emphasizing the idea that civil engineering texts, as part of the technical discourse, favours participants, entities which remain in the discourse rather than processes.
- As regards the verbal constituent, simple present tense and the passive voice are clearly preferred to the other tenses, aspect and voice. Modal verbs are the most non-homogenous aspect of the verbal features we studied.
- Civil engineering texts make use of plenty of adjectives, the most widely used category being that of descriptive adjectives.

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