Magazine of Concrete Research

Guidance on writing papers on concrete research for publication

Abstract

This paper provides guidance to authors of research papers on concrete materials and concrete structures. A guiding principle is to provide sufficient technical information so that the reader can fully understand your research and can compare your research with their own research or research of others and understand why your findings may be different to others.

Avoid vague terms such as compressive strength or tensile strength (which one?). Be precise. Much of the detailed guidance is to ensure that your research is fully understood by the reader. Papers that follow the guidance given in this paper are more likely to be accepted for publication and less likely to be sent back to the authors for clarification.

While the main objective of this paper is a check-list for papers being submitted to the Magazine of Concrete Research, some of the comments relate to the planning of the research and so potential authors are advised to read this paper when planning their research.

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Introduction

Most researchers want their work published in a prestigious technical journal such as the Magazine of Concrete Research, but to achieve this desire the paper has to pass through a peer review process. If the paper is badly written, what was done is not clearly explained or the reported work is not substantive, the paper is likely to be rejected. This paper is written by two people who have experience as peer reviewers and it identifies common reasons why papers on concrete research are rejected or sent back to the authors for revisions. The guidance provided aims to promote good practice, improve consistency and share experience in writing, reporting and reviewing concrete research. The ultimate goal is that research outputs can be disseminated to a wider international audience and increase their impact. Authors who follow the guidance in this paper are more likely to have their papers accepted and published.

A common problem identified by the authors with current guidance on how to write technical papers is that in general they are not subject-specific. Some exceptions can be found, e.g. Shokeir (2013) for medical science. To the author's best knowledge, with one exception, similar papers for concrete research do not exist. The exception is the joint publication of the Quarry Products Association, British Cement Association and the Concrete Society giving guidance on the use of terms relating to cement and concrete (Harrison and Bond, 2003). Most of the guidance available in the past was developed by Doctoral Training Schools within different universities and research institutions which were used for training early stage researchers with very different backgrounds and fields of research. Some examples of general guidance include the paper by Detwiler and Darwin (2001) from Concrete International or the teaching notes by Ashby (2005) from Cambridge University. Editorial notes in some specialised journals on concrete and materials can give some guidance, however, this is normally written in very general terms. This paper addresses specific issues in technical writing of papers on concrete research with either a material or structural focus.

This paper does not address matters of house style or the process of submitting a paper as these topics are already covered by information provided on the relevant websites.

General principles

As a general principle when the research is reported, provide enough technical information so that another researcher can understand why the data does, or does not, agree with other researchers, or for them to repeat the experiments to see if they get the same results.

The paper needs to be in good English with a clear logical structure. English, like many other languages, has a number of words that are often incorrectly used. Help with finding the correct word is found in various books (Trask, 2001; Amis, 1997).

The literature review should demonstrate the authors understanding of the previous literature on the subject. Simply reporting that paper 'A' showed a 20% increase in the property while paper 'B' showed a 20% reduction is not very helpful. The author should try and briefly explain why there is this difference, e.g. one paper compares at equal w/c ratio while the other paper compared at equal 28 day strength; one took the addition fully into account for the w/b ratio while the other paper used a k-value approach. When reviewing the literature it is also important to identify and report the basis for the comparison, e.g. at equal 28 day strength, at equal w/c ratio. The inconsistencies and knowledge gaps identified and discussed in the literature review will introduce and justify the novel work presented in the paper.

One of the first things a reviewer does is to check the substance of the paper. A recent trend is to split a piece of research into several papers. While this is reasonable if each paper has substance, too often the resulting papers are lightweight and are likely to be rejected.

Papers are required to be original and the reviewers try to check that this is the case.

Papers on material research often compare performance with a reference concrete. While by the time papers are being drafted it is too late to change the reference concrete, a poorly selected reference concrete is likely to lead to the paper being rejected. Decades ago the reference concrete was almost universally a CEMI concrete with no admixture, but such a concrete does not reflect modern concrete practice. Most concretes contain at least one admixture and this should be reflected in the choice of reference concrete.

Some papers select as the reference concrete a concrete that is not accepted as being resistance to the form of deterioration being investigated, e.g. a normal Portland cement (CEMI) concrete for sulfate resistance. While the paper may show that the resistance of concrete with the constituent under investigation is better than the (non-resisting) reference concrete, what potential users of the research want to know if whether the concrete with the constituent under investigation is as good as or better that concretes already accepted as being resistant to the form of deterioration.

In papers on structural concrete, the equivalent problem is comparing performance against a control structural member with given physical and mechanical properties (e.g. dimensions, reinforcement quantities, material properties). The decision of what represents a good control test is also critical and needs proper justification. Two scenarios can be adopted, viz. one in which the values of the parameters represent common design/construction practice for a context described by the researchers and the second case corresponds to parameter values leading to well-controlled state of stresses/strains and mode of failure. The scaling of test models also needs to be justified and reviewed carefully, this is critical in some cases and can lead to papers being rejected mainly on this consideration.

Another factor that will be checked is if two parameters are being changed, e.g. use of an addition and use of an admixture, whether the research identified how much of the change in performance was due to the addition and how much was due to the use of an admixture. This is common issue in reporting concrete research, when several parameters are changed simultaneously in a parametric analysis the influence of a single parameter cannot be isolated.

For design purposes, many engineering properties of concrete are estimated from the compressive strength, Table 1.

Table 1. Properties of concrete in EC2 (CEN, 2004) that are estimated from the compressive strength

Creep
Drying shrinkage
Modulus of elasticity
Strain
Tensile strength

A minimum compressive strength is a requirement for all designed concrete, regardless of the constituents used to produce the concrete. Papers on engineering properties that compare performance on the basis of equal 28 day strength are more likely to be accepted for publication and more likely to be used by industry. For example it is known that at constant w/c ratio, as the percentage of recycled concrete aggregate (RCA) increases, the compressive strength decreases while the creep and drying shrinkage increase. From an application viewpoint, what the research should be identifying is whether the increases in creep and drying shrinkage are significant when the concrete with RCA has the same compressive strength.

Too frequently exaggerate claims are made, often with respect to durability or sustainability. Durability has many aspects and while the use of a specific constituent may improve one or more aspects of durability, there are usually other aspects where the performance is worse. For example, the use of ground granulated blast furnace slag improves chloride resistance compared with CEMI concrete at equal w/c ratio, but its carbonation resistance is worse.

Sustainability is more than global warming potential, which is a single, albeit important, aspect of the environmental pillar of sustainability. For example using recycled concrete aggregates will reduce the use of primary aggregates, but crushing and transport impacts may outweigh this benefit giving it a higher environmental and sustainability impact over the use of primary aggregates. Another pillar of sustainability is economy, very few studies show a rigorous approach on the cost implications of the proposed research which can be significantly different depending which level is investigated (material, structural member, structure system, infrastructure system).

Be precise and support the claim with your research or the literature.

A trend when referencing papers has been to cite your own or colleagues work and while this is justified if the point being made is fairly attributed to them, too often the point being made has been established by other research decades previously. Award credit where credit is due. In this context, researchers should not be reluctant to cite references that are old if the work is worth citing; however, reviewers will also look at whether the references listed reflect recent work and current practice. A short list of references does not generally cause a good impression amongst reviewers and readers.

Constituents

Concrete comprises constituents usually conforming to a product standard. The word 'materials' is also acceptable but constituent materials, ingredients, raw materials and wastes are not acceptable terms. The phrase 'constituent materials' is tautology; the word 'constituents' is sufficient.

The word 'ingredients' is usually associated with making cakes and it is not the normal word used for the constituents of concrete.

Concrete does not use raw materials as the materials used in concrete are processed materials usually conforming to a product standard. Do not use this term. Some of the constituents used in concrete may at some point in their life cycle been classified as wastes. Fly ashes and recycled aggregates are two such examples, but by the time they are used in concrete they are products conforming to product standards and no longer classified as wastes. In Europe fly ash would be in accordance with EN 450-1(BSI, 2012) and recycled aggregates would be in accordance with EN 12620 (BSI, 2013). The reasons for this are:

– to ensure customer acceptance;

– to avoid the producer having to hold a waste license (expensive).

The technical description of the constituents needs to provided, but not the source of the constituent. While the provision of constituents for research purposes is much appreciated, naming the source in the main text is not appropriate in a technical journal. In special cases it may be acceptable to mention the supplier in the acknowledgements.

The MCR and many other journals on concrete research will not publish papers where one or more of the constituents are 'secret' materials.

The following sub-sections provide guidance on some specific constituents.

Additions

'Additions' is the European word for fine inorganic powders added directly at the concrete mixer. In North America they are called 'supplementary cementitious materials (SCMs). The use of either term is acceptable but use one or the other consistently in the paper. Do not describe these constituents as ‘mineral admixtures’ or ‘additives’.

Table 2 provides some additional information about a number of additions.

Table 2. Additions

Type of addition	Comments
Calcined clay	1. Not usually a waste 2. Requires energy for its production.
Fly ashes	1. At some point in their life cycle they would have been classified as waste. 2. Pozzolanic material
Ground granulated blast furnace slag	1. Never a waste; it is a by-product of iron making 2. Latent hydraulic material 3. Demand is greater than supply
Metakaolin	1. Product manufactured from china clay; never a waste. 2. Pozzolanic material. 3. Requires energy for its production.
Natural pozzolana	1. Natural rock, never a waste. 2. Pozzolanic material.
Limestone	1. Depending upon the source it may or may not have been classified as a waste. 2. It is neither pozzolanic nor latent hydraulic, yet it is treated as part of the ‘cement’.
Pigments	1. Never a waste; usually a metal oxide. 2. Not taken into account as part of the ‘binder’.
Silica fume	1. Never a waste; it is a by-product of silicon or ferrosilicon alloy production. 2. Very reactive pozzolanic material.

Aggregates

In the table of mix proportions, when reporting the mass of aggregates per cubic metre identify if these are the dry masses or saturated surface dry masses. It is also essential to provide the water-absorption of the aggregates if the masses are the dry masses and the water content is the total water content. This information will enable the reader to determine the w/c ratio (see Section on Concrete Mix Proportions).

When recycled aggregates are used in the research, it is important to explain if these materials were produced in the laboratory (thus being free of any impurities) or taken from a construction site. If they were taken from a construction site, were the impurities such as wood and plastic removed prior to use?

In structural concrete papers, it is becoming more relevant with new code developments to provide basic information on the aggregate used in the mix, in particular information on the coarse aggregate. Recently design formulae and constitutive models in numerical tools now include a higher level of refinement in which the size of aggregate affects parameters such as the fracture energy or crack roughness which are considered in the models. Therefore, it is recommendable to specify the type of aggregate used in the concrete and the maximum aggregate size, whether this is the nominal maximum aggregate size or follows another standard definition (e.g. upper aggregate size as in EN206:2013).

Binder/Cement

Clarity in this area of reporting is essential and it is not helped by different uses of the word 'cement'. In EN 206 (BSI, 2013 (1)) cement is defined as:

'*finely ground inorganic material which, when mixed with water, forms a paste that sets and hardens by means of hydration reactions and processes and which, after hardening, retains its strength stability even under water*'

This definition of cement covers both cement supplied by a cement producer and 'cement' formed in a concrete mixer by mixing together a cement and a pozzolanic or latent hydraulic addition. A further complication is that often additions are not treated as being equal to the same material if it were part of the cement, e.g. in the k-value concept. To reduce confusion, it is better to describe the sum of the cement content as supplied by a cement producer and the addition content as the binder content.

There are numerous types of cement and it is necessary to define the one that is used in the research.

Fibres

Include in the paper the fibre material, e.g. steel. polymer, glass, and shape, e.g. straight, crimped, hooked, the length and diameter and relevant engineering properties, e.g. tensile strength, modulus of elasticity, but do not include the trade name of the product. If any of the reported properties are simply taken from the data supplied by the manufacturer, say so.

The mix proportions must include the quantities of fibres per cubic metre and the mixing procedure should cover where in the mixing process the fibres were added. If tests were undertaken to check the uniformity of fibre distribution these should be reported or if the mixing procedure has already been proven to give a uniform distribution of fibres, say so.

When reporting the influence of the fibres on the properties of the concrete, report the mode(s) of failure, e.g. matrix failure, fibre failure, and the ranges over which these modes of failure occurred.

Concrete mix proportions

A table with concrete mix proportions is generally needed when reporting tests, regardless whether the paper is focused on materials or structures. In the experience of the authors, it is rare to see a table of mix proportions submitted for publication where one or more entries need to be clarified. Firstly by convention, the mix proportions are expressed as the masses or in the case of water and admixtures, litres per cubic metre. If percentages are given, for example the proportion of addition in the binder these are expressed as 'm/m%' and not 'wt%'. The weight of an object is the force applied by gravity to an object and the unit is the Newton. The mass of an object is expressed in kilograms.

If the variations in mixes involve replacing one constituent with a constituent of different relative density, the yield will be different and the masses of the other constituents need to be adjusted so that the total yields one cubic metre.

The aggregate masses need to be identified as either the dry or saturated-surface dry masses. The water content is taken to be the effective water content unless stated otherwise. If it is the total water content, this must be stated together with the water absorption of the aggregates. This information will help the reader determine the free water/cement ratio.

By convention the water/cement ratio (water/binder ratio) is taken as the free water/cement ratio (water/binder ratio). If it is the total water/cement or total water/binder ratio this must be stated.

It is also necessary for the reader to understand if this value is:

W/C where C is the cement supplied by the cement producer;

W/(C + A); or

W/(C + k*A).

If the k-value concept has been used, provide the value of 'k' and the proportion of the addition taken into account. This is important for understanding the results. For example if limestone is used as an addition under the k-value concrete and only part of it is taken into account when calculating the binder content, the remaining limestone will absorb some of the free water and thus the true water/binder ratio will be less than the calculated value. Understanding that this happens helps interpret different conclusion about the impact of using limestone as an addition.

Strength

There are several measures of compressive strength and they differ significantly. The main reason for these differences is due to the friction between the concrete specimens and the test machine platens. If there were no friction the failure would be vertical cracks. Because of this friction, a cube has a higher strength than a 2:1 cylinder. According to EN 206 (BSI, 2013(1)) on average the 2:1 cylinder strength is 0.82 times the cube strength, although this relationship is not constant for high-strength concretes.

Often, but not always, the type of compressive strength can be found somewhere in the text, but it is no more effort to use the correct term and this will indicate that the authors understand that there are differences.

The following terms should be used as appropriate:

cube strength (say what size);

2:1 cylinder strength;

uniaxial compressive strength (where there is no friction between the test machine and the specimen);

core strength (give diameter and length to diameter ratio);

mortar prism strength.

By definition a cube has equal sides and saying 'testing was undertaken on cubical specimens (150mm x 150mm x 150mm)' is tautology. 'Testing was undertaken on 150mm cubes' is all that is needed.

Another important aspect is reporting the age of the concrete at the day of the structural test to clarify whether the compressive strength reported is a good indication of the actual strength. If this information is not available, the authors should explain the adjustments made to account for this and whether the strength has reached its plateau. If the test specimen is large using the concept of maturity may be helpful in understanding the test results.

Tensile strength is also a function of the test method. The 'weakest link' theory is a good way to understand the differences. In this theory once a crack has stated it spreads and the greater the area in tension the more likely it is that it will contain a weaker link. Consequently a direct tensile test gives a lower tensile strength than a four-point bending test, which in turn will be lower than a three-point bending test. Be precise in describing the tensile strength that has been measured.

The following terms should be used as appropriate:

direct tensile test;

four-point bending test;

three-point bending test;

splitting tensile test.

Many constitutive models for concrete used in computational analysis are highly sensitive to the tensile strength adopted in the model. Therefore, it is important to be clear on whether the tensile strength was derived from testing or estimated from the compressive strength; in the latter, the relationship used between the compressive and tensile strengths will need to be reported.

Test results and precision

It is important for the reader to know if the test result is a single measurement or the average of a number of measurements. There will be more confidence in the test result if it is the average of a number of measurements. All papers should contain this information.

Many test procedures require the test result to be rounded to some fixed unit. For example the slump test to the nearest 10mm. For research purposes it is acceptable to be more precise than that required by the test procedure, e.g. recording the compressive strength to the nearest 0.1 MPa; however, two decimal places is not justified.

Test procedures have, or should have, a precision statement often in the form of the repeatability and reproducibility of the test. In general for research purposes the repeatability is the more relevant value as the testing is more likely to have been done by the same person using the same equipment. If the difference between test results is less than the repeatability of the test, the possibility that the trend is simply the result of testing variability should be considered.

In structural testing, measured values of the main parameters considered in the test should be reported. If this information is not available for all the parameters and nominal values are reported instead this should be stated and good quality control conditions should be put in place to limit testing variability.

A few common issues in reporting results from structural testing are summarised below:

– has the self-weight of the test specimen and loading rig been taken into account in the results?

– has the exact position and size of the loading and bearing plates been provided?

– does the test rig impose any lateral constraints leading to any undesired in-plane confinement?

– has the detailing of the reinforcement in the tests been provided accurately? e.g. position of rebar, bar spacing, concrete cover, effective depth, anchorage details.

A controversial point in structural testing of concrete members is scaling of the specimens due to potential size effect issues. The authors should demonstrate that such issues were taken into account when conceiving the experimental programme. Structural testing on very thin or small specimens is also problematic and should be avoided since controlling the variability of some of the geometric variables is cumbersome; tolerances should be scaled accordingly. Another common issue related with the geometry of specimens in cases where the loads are very close to the supports leading to the development of a direct strut. This effect can be intended or unintended by the researchers and it will affect significantly the results.

Reporting modes of failure incorrectly can mislead the reader and test results could be misinterpreted or misused. Unfortunately, there is not an agreed unified terminology for different modes of failure in structures and providing only a single term to categorise the mode of failure can lead to misinterpretations. It is therefore advisable to provide a narrative of the mode of failure observed with a sequence of observed/measured events. It is important to distinguish between local failure of the material and global failure of the member. For example, a flexural failure in a beam can be ductile or brittle depending on whether the cross section is under or overly reinforced respectively (i.e. steel yields only in the former case). There are cases where flexure, shear and bond failures can occur almost simultaneously and therefore authors need to review this carefully before making a final statement. Also it is important to clarify what is the systematic definition of the failure point in the load-displacement curve; some authors take the maximum load whereas others use the maximum displacement as a reference.

Coefficient of determination and correlation coefficient

In statistics, the coefficient of determination, denoted R^2 or r^2 and pronounced "R squared", is the proportion of the variance in the dependent variable that is predictable from the independent variable (source: Wikipedia). It has values between 1.0 and zero. This is not the same as the correlation coefficient but the two values are linked. The correlation coefficient (denoted R of r) is a statistical measure that calculates the strength of the relationship between the relative movements of two variables. The values range between -1.0 and 1.0. The square of the correlation coefficient is the coefficient of determination.

Computational models, conceptual/physical models and design expressions

Papers on concrete research often include results from computational models such as Finite Element Analysis (FEA) or conceptual/physical models based on theoretical considerations with simplifying assumptions. Two important aspects which reviewers are likely to check are (a) whether the purpose of the computational/conceptual models is declared and whether it is consistent within the context of the research work and (b) whether the models were validated and/or verified rigorously. The purpose of the models should go further than just acting as a tool in a prediction exercise of test data. To enrich this discussion one can include comments on the level of refinement adopted in the model, the intended level of accuracy and its suitability to the research problem in hand.

Terms “validation” and “verification” of models are often used interchangeably in papers which is not correct. Figure 1 shows a well-established definition and context of these terms amongst the modelling community. Terms “calibration” and “benchmarking” are also different; the former refers to some sort of regression exercise whereas the later refers to the comparison against a structural problem or test set up for which the answer is well-known.

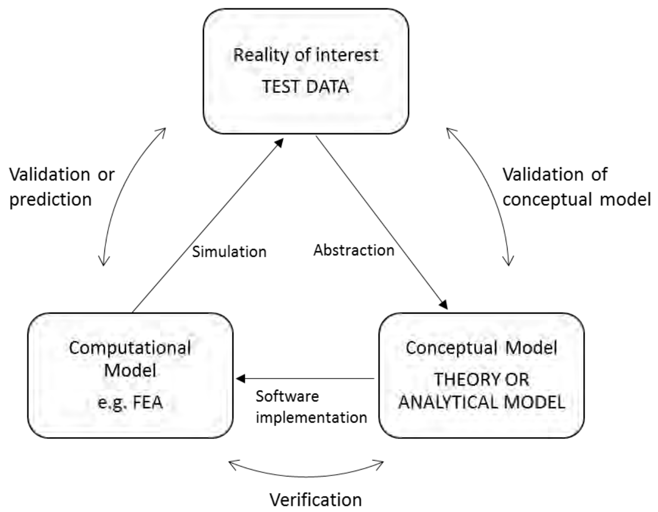

Figure 1: Validation and verification processes in computational and conceptual models ASME (2016)

Another point of conflict when reporting results from computational/conceptual models is deciding how much information should be provided about the model itself and its variables. This depends on the context of the paper but as a general rule of thumb a minimum level is needed so that the results can be reproduced. There is also a recommendable upper limit; providing too much information which has no effect on the results can also be viewed negatively. For computational models, researchers are advised to read recent international guidelines for modelling, analysis and simulation (e.g. National Agency for Finite Element Methods and Standards (NAFEMS) and The American Society of Mechanical Engineers (ASME)). Further specialized recommendations for reporting FEA results and modelling of concrete structures can be found in fib bulletin 45 (2008) and Rijkswaterstaat Centre for Infrastructure Report RTD:1016–1011 by Hendrix et al. (2017).

Another point of confusion in papers is when authors refer to "strength" of a specimen without clarifying whether this is the experimental value (real strength) or a theoretical prediction. Often authors claim that the "strength" is found to increase or reduce for a certain parameter where in fact they mean that the model predicts the strength to increase or reduce with that parameter. It can also be misleading to talk about "strength" in the common case of a parametric analysis when using a model with parameter values which are significantly different to the ones used in the validation and verification of the model. The results for this "extrapolated predicted strength" should be considered as tentative until tests become available for that test region.

Computational models are highly popular in concrete research, especially to obtain some insight if tests are not available. However, the relevance of conceptual/physical models is also widely acknowledged for verification purposes and for the development of simplifying design expressions. Empirical formulae are still used although in recent years there has been a clear inclination towards conceptual/physical models as show in the development of Model Code 2010 (fib, 2010). A significant amount of papers analyse test data using formulae from different design codes. In such cases authors often miss that design expressions can hide some level of inbuilt conservatism (in most cases). In shear design for example, it is frequently mentioned in Technical Committees that some existing formulae giving rather conservative results are not meant to be used as "prediction tools" but as "design tools". For example, the first Level of Approximation (LoA-I) in Model Code 2010 is not meant to be used as a predicting tool but rather as a quick design check to decide whether further calculations are needed. Therefore, it is recommended that authors are aware of the context of the design formulae used in their comparisons before arriving to any misleading conclusions.

Conclusions

There is a common core of reasons why papers on concrete research that have been submitted for publication are rejected or sent back to the authors for amendment. Many of these common reasons are described in this paper. If authors follow the guidance given in this paper there is a higher probability that the paper will be accepted for publication.

While this paper is aimed at authors wanting to have their research published in prestigious technical journals, the advice and guidance is equally applicable to student projects.

References

AMIS K (1997), The King's English, Penguin Modern Classics, p242.

ASHBY M (2005), How to write a paper, 6th Edition, Engineering Department, University of Cambridge.

ASME (2006), American Society of Mechanical Engineers PTC 60 Committee, "Guide for Verification and Validation in Computational Solid Mechanics", American Society of Mechanical Engineers, New York.

BSI (2012), BS EN 450-1, Fly ash for concrete. Definition, specifications and conformity criteria.

BSI (2013), BS EN 12620, Aggregates for concrete.

BSI (2013(1)), BS EN 206, Concrete – Specification, performance, production and conformity.

CEN (2004), Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings.

DETWILER R, DARWIN D (2001), How to write a good technical paper, Concrete International, 52-55.

fib (2008), Practitioners' guide to finite element modelling of reinforced concrete structures, fib bulletin 45.

fib (2013), Model Code for Concrete Structures 2010, Ernst & Sohn, Berlin, Germany, p434.

HARRISON T A and BOND G, Guidance on the use of terms relating to cement and concrete, The Concrete Society, 2003, ISBN 0 7210 1594 8.

HENDRIKS M A N, DE BOER A, BELLETI B (2017), Guidelines for nonlinear finite element analysis of concrete structures, Rijkswaterstaat Centre for Infrastructure, Report RTD:1016–1011: 2017.

SHOKEIR A A (2013), How to write a medical original article: Advice from an Editor, Arab Journal of Urology, 12, 71-78.

TRASK R L (2001), Mind the gaffe, The Penguin Guide to Common Errors in English, p300.