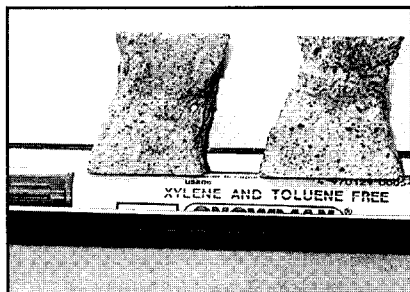


DISCUSSION

The achievement of uniformity of straining during concrete cube testing in South Africa

I Luker (Journal of the South African Institution of Civil Engineering, 45(1): 2-8)



DISCUSSION

The author offers an alternative approach to the compression test of specimens, suggesting that testing should be rather strain-rate controlled instead of applying a uniform loading rate as specified presently not only in SABS Method 863 (compressive strength of hardened concrete), EN 12390-3 (compressive strength of specimens by using a testing machine with force control [EN 12390-4]) and also in SABS EN 196-1 (Method of Testing Cement, Part 1: Determination of strength).

Whilst the author criticises the desirability of this condition (constant loading rate) he provides no real solution to testing laboratories which have to prove compliance with this requirement as specified worldwide.

Modern compression testing machines are often combined with a flexural strength testing attachment also calling for a controlled loading rate, and the same applies if one undertakes tensile splitting or direct tensile testing.

Could the author explain which approach he would suggest to these tests.

Furthermore, the statement that the introduction of the 'strain measurement' method will enable the manufacture of (local?) machines to lower standards and costs has to be read with caution.

Some years ago a South African supplier manufactured a number of compression testing machines for EN (ISO) prism strength. A few machines were sold locally until a number of serious shortcomings with this kind of equipment were detected by the writer's organisation. The supplier lost subsequently the South African market but managed to sell the rest of his machines to some less informed and unfortunate customers 'North' of South Africa.

The picture above shows failed prism specimen after inappropriate compression testing in one of the above-mentioned 'local' and 'cheap' units as encountered

by the writer's organisation during a recent laboratory audit in South East Africa. In addition, constant loading rate could also not be maintained at all.

Finally, a comment to one of the disadvantages of the strain column test as mentioned by the author: 'Determination of a testing machine would only be noticed when it was next examined with the strain column.'

Surely, proficiency testing, which is a standard procedure practised regularly between accredited laboratories in South Africa, should also detect an equipment deterioration.

These tests include the testing of concrete cubes as per BS 1881: Part 127: 1990 'Method of verifying the performance of a concrete cube compression machine using the comparative cube test'.

Another method is 'eccentricity' testing, using a total of 15 concrete cubes cast from a single batch of concrete. Strength testing is as follows:

Three cubes each are placed into the centre, and three each eccentrically to the centre line by a given distance at four positions (North, East, South, West). One can obtain a rather good idea if uniformity of straining is achieved and the swivel head of the top platen locks properly.

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RESPONSE

I am grateful to Dr Amtsbüchler for his comments, and reply to them as follows.

Worldwide adoption of 'uniform loading rate' standard

I am sympathetic to the position of the professional who finds himself constrained to comply with national standards that are badly misleading in their requirement of a uniform loading rate. The use of this procedure was criticised as long ago as Rusch 1960, and strain rate control advocated. However, it has not been adopted, probably because of the expense in the past of a sufficiently robust and accurate strain measurement method.

Fortunately the measurement of strains for the purpose of checking on the

non-uniformity of strains at maximum load on the specimen does not interfere with the continued attempt to use a uniform loading rate, so a laboratory can do both simultaneously. The potential size of the effect on measured concrete strength from non-uniform straining is greater than that from the varying strain rates that come from attempts to follow a uniform loading rate, so I suggest a sensible way forward is for us to incorporate strain measurement into concrete testing initially to deal with non-uniform straining effects, and when the facility for measurement of strains is sufficiently common on concrete testing machines, switch to a strain rate control standard. I see this progression as one aspect of materials testing in which South Africa can play the leading part.

Tests for tensile strength of concrete

The use of a uniform straining rate is desirable when the effect of different rates on the measured strength is significantly great, as it is for compressive strength. I do not know whether the tensile strength is affected by varying strain rates, but I doubt it. My logic is that tensile failure occurs at very low strains, when the stress-strain behaviour of the material is still linear and elastic. Strain rate effects are usually associated with plastic behaviour.

Bad concrete testing machines

Dr Amtsbüchler mentions his unfortunate experience with machines from a particular source that had 'a number of serious shortcomings' and show a picture to illustrate 'inappropriate compression testing' of small prisms by these machines. He does not specify what particular faults he observed, but the pictures seem to me to show the result of non-uniform straining, so the measured strength would have been lower than it should have been. Measurement of the strains in these tests in the manner advocated in my paper would have detected these faults, and (assuming the agreement of all concerned), the effect of the non-uniformity on the strength could have been corrected.

In the past, a reaction to such an experience has been to buy a machine from a manufacturer whose reputation

one trusted more. I am aware of large sums of money being paid for imported machines from overseas companies, when much less costly locally manufactured machines would have been adequate for the purpose. The important point is that one must have a way of checking the performance of all machines – expensive and cheap ones.

Comparative cube tests to detect inadequate machine performance

It has been suggested that comparative cube tests, including deliberately offsetting some cubes from the centreline of the machine, can show whether a machine is insufficiently stable. This indication can come from two sources: (i) if a machine gives strengths significantly different from other machines; and (ii) if the

pattern of cracks on the cube is non-uniform.

Cubes used for comparative tests between machines will be made and tested very carefully. When the cubes are properly compacted, with uniform distribution of coarse aggregate, and centrally placed in the machines, the straining is likely to be uniform and all machines to give similar results. Non-uniform straining is more likely to occur if the aggregate is segregated in, say, a high slump concrete, or if the cube is carelessly positioned in the machine. Such conditions occur in practice, and a rough attempt to simulate them is to deliberately offset from the machine's centreline some of a uniform batch of cubes and examine the cracks. I have observed the following with regard to the crack patterns on cubes:

- The pattern often becomes apparent only when the straining of the cube

is continued after the maximum load point has been passed, by which stage non-uniformity of straining is irrelevant.

- Unless the non-uniformity of straining is extreme, the pattern of cracking on the cube after the test gives only an unclear guide to the general performance of the machine.
- In normal commercial testing, one cannot rely on the machine operator to notice a bad cracking pattern and bring it to the attention of his supervisor.

I therefore suggest that comparative cube testing and observation of cracking patterns are not sufficient to improve or even maintain the standard of cube testing in South Africa.

I Luker