Comparison of Chinese and American About Performance Test Methods for New Mixed Concrete

Jun Liu, Ping Zhang, Qin Wang, Guoqiang Bai, Zeng Liang Li and Jun Wang

ABSTRACT

This paper analyzes and compares the performance test methods of new mixed concrete in Chinese and American standards from the perspectives of standard setting, concrete density, air content of concrete and mortar. The comparison results show that when dispose experimental results, the Chinese and American standards toward concrete density test are different. The American standard requires the test results accurate to 1 kg/m³, but the Chinese standards require the test results accurate to 10 kg/m³. When measuring the air content of concrete and mortar, American standard has correspond measuring method for different kinds of concrete. However, the Chinese standard only recommends use gas cylinder in the measurement of air content. It is suggested to improve the specialty of instrument selection, the rigor of experimental procedures and the accuracy of experimental results in the future revision of Chinese regulations. To promote our industry standards more advanced, standardized and scientific, we hope this new standard can promote the progress of industry.¹

INTRODUCTION

This article selects the American standard ASTM C 138/C 138M–09: Standard test method for density (unit weight), yield, and air content (gravimetric) of concrete, ASTM C 173/C 173M–09: Standard test method for air content of freshly mixed concrete by the volumetric method, ASTM C 231–09: Standard test method for air content of freshly mixed concrete by the pressure method, as a comparative research

¹Jun Liu, Ping Zhang, Qin Wang, Guo-qiang Bai, Zeng-liang Li. China West Construction Group Xinjiang Co., Ltd, Urumqi, China
Jun Wang. China West Construction Group Co., Ltd, Cheng Du, China
object. By analyzing the concrete density test, concrete output calculation and the air content of concrete and mortar with their equipment, experimental procedures and treatment of experimental results, compared and analyzed the Chinese and American standard from different angles and aspects. To explore the differences, advantages and disadvantages of the instruments and test methods for the performance test of fresh concrete between Chinese and American standard. It will provide reference for the technical specification of concrete in the future revision.

**Standard Setting Comparison**

In the American standard, the performance test standard of fresh concrete is mainly ASTM-cseries, which mainly includes concrete density, yield and air content measurement, and so on. Among them, C 138/C 138M mainly introduces the new mixed concrete of density, output and air content. C 173/C 173M mainly introduces use isopropyl alcohol and water displace air volume in concrete to measure air content of the new mixed concrete and C 231 mainly introduces the relevant test procedures of measuring the air content of fresh concrete by observing the volume change of concrete under variable pressure.


**DENSITY TEST OF CONCRETE**

The applicable scope of concrete density test methods in the Chinese standards and the American standards are different. The Chinese standard GB/T 50080-2016 is applicable to test method of performance on ordinary fresh concrete (dry apparent density from 2000 kg/m³ to 2800 kg/m³ of concrete). The American standard C 138/C 138M test of concrete density, yield and air content measurement. The standard does not apply to plastic-free concrete, as is commonly used in making pipes and concrete blocks.
TABLE 1. COMPARE STANDARD SETTING OF CHINESE ABD AMERICAN NEW MIXED CONCRETE.

<table>
<thead>
<tr>
<th>Comparative items</th>
<th>Chinese Standard</th>
<th>American Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air content of concrete</td>
<td>Test method of air content of concrete in GB/T 50080-2016</td>
<td>Air content test method of concrete by pressuring in C 231</td>
</tr>
<tr>
<td>Air content of mortar</td>
<td>Test method of air content of mortar by instrument in JGJ/T 70-2009</td>
<td>Air content test method of mortar by pressure method (C 231), volumetric method (C 173/C 173M), and weighting method (C 138/C 138M).</td>
</tr>
</tbody>
</table>

TABLE 2. THE RELATION BETWEEN THE MAXIMUM NOMINAL SIZE OF AGGREGATE AND THE VOLUMTRIC CYLINDER USED IN THE CHINESE AND AMERICAN STANDARD.

<table>
<thead>
<tr>
<th></th>
<th>Chinese standard</th>
<th>American standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum nominal size</td>
<td>The measuring capacity (L)</td>
<td>Maximum nominal size of aggregate (mm)</td>
</tr>
<tr>
<td>of aggregate (mm)</td>
<td>≥5</td>
<td>25.0</td>
</tr>
<tr>
<td>≤40</td>
<td>37.5</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>14</td>
</tr>
<tr>
<td>&gt;40</td>
<td>The inner diameter and height are greater than 4 times of the maximum nominal diameter of capacity tube</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>112</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>

**Instrument And Equipment Comparison**

Most of the instruments used in the test of concrete density are the same or similar to those used in the Chinese standard and the American standard, mainly including the balance, rammer, capacity barrel (the difference between China and America is shown in TABLE 2), glass plate and rubber hammer. The difference is that the American standard equipment contains the instrument insertion vibrator, the Chinese standard is the instrument vibrator. In addition, the size, precision and index requirements of some instruments are different in the Chinese and American standards: 1) The accuracy of the balance in the American standard is 45 g, while the Chinese standard is 10 g. 2) The diameter range of the tamper in the American standard is 16mm±2mm, while the Chinese standard is 16mm±0.2mm. According to the comparison of standard requirements, GB/T 50080-2016, JG/T 248 requires higher dimensional accuracy. However, the American standard C 138/C 138M-09 requires more detailed about construction of the instrument aspect.

**Comparing Experiment Steps**

There are some certain difference between the American and Chinese standard in concrete density measurement procedure:
1) The Chinese standard has the step about measuring capacity barrel volume, while the capacity barrel volume in the American standard is fixed, the slump of 90mm as the boundary, vibrates with the vibration table when the slump is no more than 90mm, and tamp with the rammer when the slump is greater than 90mm. In the American standard, it is required when the slump is greater than 75 mm use insert smash to dense, when the slump is less than 25 mm use vibrate to dense and when the slump is between 25 mm to 75 mm use insert smash or vibrate to dense.

2) Inserted with tamper, the American standard is concrete in three layers to be included in the measuring tool. Chinese standard of concrete is divided into two layers in the capacity of the tube, and each layer of the two standards of smash times also has the difference, in the Chinese standard when using more than 5 L capacity of the tube each layer smash times less than 12 times/10000mm$^2$.

3) The Chinese standard has the operation requirements for measuring the density of self-compacting concrete, while American standard has made extremely detailed operation requirements for scraping the surface after concrete compaction.

**Disposing and Comparing Experimental Results**

Chinese and American concrete density measuring formulas are basically same, but the accurate values are different. The result of the American standard will be accurate to 1.0kg/m$^3$, while the Chinese standard will be accurate to 10kg/m$^3$.

**AIR CONTENT TEST OF CONCRETE**

In the American standard, there are three methods to determine the air content of concrete: pressure, volume and weight method. Among them, C 231 is applicable to concrete made of relatively dense aggregate particles, and needs to measure the correction coefficient of aggregate, which is not applicable to non-plastic concrete. C138/C138M and C173/C173M are applicable to light aggregate concrete, air-cooled blast furnace slag or high-porosity aggregate concrete, with a wide range of application.

The test method of concrete gas content in GB/T 50080-2016 is applicable to ordinary concrete with dry apparent density of 2000kg/m$^3$~2800kg/m$^3$, and is suitable for the measurement of air content of concrete mixtures with the maximum nominal particle size of aggregate not greater than 40 mm.

**Comparison of Instruments And Equipment**

**COMPARISON OF EQUIPMENT TYPES**

In the American standard C173/C173M mainly includes the gas meter, isopropanol measuring vessel, water injection vessel and so on. C231 mainly include gas meter, measuring vessel, cover assembly, calibration vessel, etc. Which the gas
measurement score is a-type gas meter and b-type gas meter. The gas content test equipment in GB/T 50080-2016 mainly includes gas content meter, vibration table and electronic balance, which is similar to the type of American standard. In the above instruments, the gas content meter in the Chinese standard is similar to the b-type gas quantity calculation in C231, which has a certainly contrast significance.

**COMPARISON OF STRUCTURE OF GAS CONTENT METER**

In the C231, b-type gas meter mainly contain components to measure bowls, pipe clamp, pump, air chamber, the main valve, petcock, purge valve, pressure gauge, etc. JG/T 246-2009 tester is mainly used in apparatus to determine air content of fresh concrete includes components for pressure gauge, operated valve, exhaust valve, the fixed clamp, cover body, container, etc. Most of the components is the same or similar, but the structure of the Chinese standard of instrument equipment requires more specific, the pressure gauge range 0 MPa to 0.25 MPa.

The measurement of air content in fresh concrete by volume method, the mainly components of the apparatus include measuring bowl, flange with gasket, top part, neck scale, waterproof cap in the C173/C173M. A-type gas meter (C231) mainly includes measuring vessel, pipe clamp, air pump, pressure gauge, neck mark, etc. The two kinds of gas meters are different from the components and principle of the measuring instrument in the Chinese standard, and there is no comparability.

**Comparison of Experimental Procedures**

The method adopted in the Chinese standard is similar to the b-type gas meter in C 231, while the a-type gas meter, volume method and weight method are too different from the Chinese standard.

1) Comparison of the determination steps of b-type gas meter in C231 with those of the Chinese standard

Before the measurement of gas content, the meter should be calibrated or checked. The correction coefficient of coarse and fine aggregate should be measured. The measurement results are more accurate in American standard. The gas content of the aggregate is measured, and the measurement results may not be accurate in the concrete feeding or mixing process in Chinese standard. C231 is required to obtain the newly mixed concrete sample according to the procedure C172 at the time of sampling. If the concrete contains coarse aggregate that does not pass through the 50-mm screen, the representative sample shall be obtained on the 37.5 mm screen by the wet separation method.

The charging and compacting methods of samples in the Chinese and American standards are different. The loading and compacting methods of concrete mixtures in GB/T 50080-2016 are determined according to the slump of the mixtures. If the slump is not greater than 90 mm, the container should be loaded in one time, and the vibration table should be used to vibrate; if the slump is greater than 90 mm, the container should be loaded in three layers, and the compacting should be done with
tamper and rubber hammer. When the test object is self-compacting concrete, it should be filled in one time, and vibration and tamping should not be carried out. The packing materials and compacting methods for samples with different slump values specified in the American standard are the same, and they are divided into three layers for interpolation and vibration according to different compacting methods. The samples are added into the container in three layers during the interpolation and the samples are added into the container in two layers during the vibration.

2) Measurement procedure of a-type gas meter

The test procedures mainly include instrument calibration, measurement of aggregate correction factor, preparation of concrete samples, sample placement and interpolation compaction and scraping, and then application of pressure to the concrete through a small manual pump. Then, to reduce the local limit, tap the side of the measuring vessel, when the pressure gauge reaches the test pressure P, read the water level reading h1 and record. For extremely crude mixtures, tap the measuring vessel until the measured gas content is unchanged. Gradually release the air pressure through the air vent at the top of the water column and tap the side of the measuring vessel for about 1 minute record water level h2.

3) The measurement steps of the volumetric method are listed

The American standard, if the concrete contains coarse aggregate particles which have not passed through the 37.5 mm screen, the representative samples should be screened on the 25 mm screen by wet screening. The two-layer packing method is used in the charging. The tamper is used and the wood hammer is used for compacting. The gas content is measured by adding water and isopropanol.

4) Gravimetric determination procedure

The measurement procedure of the gravimetric method is less. The main steps include sampling, interpolation or vibration compaction, scraping, cleaning and weighing, and calculation.

GAS CONTENT TEST OF MORTAR

Comparison of Instruments And Equipment

The mortar gas content meter used in JGJ/T 70-2009 mainly includes: pressure gauge, air outlet valve, valve stem, pump, air chamber, pot cover, measuring pot, fine-tuning valve and small faucet; b-Type gas meter in C231 mainly includes: measuring bowl, pipe clamp, pump, air chamber, main air valve, small cock, vent valve, pressure gauge, etc. The gas meter in C173/C 173M mainly includes: measuring bowl, flange with washer, top part, neck scale, waterproof cap, etc. The C138/C 138M medium gas meter mainly includes: measuring vessel, pipe clamp, air pump, pressure gauge, etc.

It can be seen from the comparison that it is similar to the concrete gas content measuring instrument, only the b-type gas meter is similar to the other gas content
measuring instrument, and other gas content measuring instruments are not comparable with the other gas content measuring instrument.

**Comparison of Test Steps**

According to C 231, if the mortar contains coarse aggregate that does not pass through the 50mm screen, the typical sample shall be screened by the wet separation method on the 37.5 mm screen.

According to the C 172, if the mortar soil contains coarse aggregate that does not pass through the 37.5 mm screen, the typical sample shall be screened on the 25 mm screen by the wet separation method. The two-layer packing method is used in the charging. The tamper is used and the wood hammer is used for compacting. The gas content is measured by adding water and isopropanol.

The instrument method and the bulk density method in JGJ/T 70-2009 all stipulate that the mortar shall be loaded into the container in three layers, and then it can be compacted with tamper and rubber hammer.

**CONCLUSIONS**

By comparing and analyzing the performance test methods of Chinese and American fresh concrete, it can be concluded that:

1) There are many differences between the Chinese and American standard, especially in terms of test instruments and equipment, samples and procedures.

2) The measurement methods of concrete density in the Chinese and American standards are basically the same, each of which has its own advantages and disadvantages.

3) There is a big difference between the American standard and the Chinese standard in the measurement of gas content of concrete and mortar. In terms of instruments and equipment, experimental procedures, and result processing, the American standard is more detailed and rigorous. Comparatively speaking, the test operation of the Chinese standard is more simple, easy to understand, and has strong operability. However, it is worth for us to reference the requirement of the rigor and precision of the American standard.

**REFERENCES**


