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New approach to resin sample preparation for strength testing

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NEW APPROACH TO RESIN SAMPLE PREPARATION FOR STRENGTH TESTING

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ABSTRACT: A new method of preparing multiple samples, from one resin mix portion, for strength testing is presented. The method is based on rapid mixing of the resin mechanically and forcing a select number of seven specially prepared moulds into the mixed resin. The system is applicable for both cylindrical and cube/prisms particularly suited for fast setting resin. The study demonstrated that the samples are easily prepared, uniform in composition, with little or no entrapped air. It was found that the samples yielded consistent uniaxial compressive strength values with a standard deviation of 0.47 and a coefficient of variation of 0.88%. The methods can be used for different sample sizes.

INTRODUCTION

There is no Australian standard for the evaluation of the mechanical properties of resins or cementitious grouts used for bolt or cable encapsulations; therefore there is no uniform method for testing resins for strength. Depending on the country of origin, resin manufacturers invariably use different specimen shapes and sizes to determine the strength properties of the resin or grout. Currently three standards available, which are likely to be used in Australia for strata reinforcement system components used in mines. They are:

1) The British Standard BS 7861: Strata Reinforcement support system components used in Coal Mines- Part 1. Specification for rock bolting (1996) and Part 2: Specification for Flexible systems for roof reinforcement;
2) American Standard for Testing Materials (ASTM) F 432- 10: Standard Specification for Roof and rock Bolts and Accessories; and
3) South African Standard SANS1534

There appears to exist a divided loyalty and preferred practices in testing for the strength of resin with regard to sample shape and size. Irrespective of the resin setting (fast, medium and slow set) the Uni-axial Compressive Strength (UCS) property is determined either by using 40 mm cubes, or cylindrically shaped samples, with varying sizes of 20, 30, 42 and 54 mm diameters. The 20 mm diameter size appears to be the most desirable size for testing fast set resin samples. In general, and in comparison with cube /prism, the cylindrical samples represent a better shape of sample preparation as well as being easily manipulated for different test needs. Normally the length to diameter ratio will be 2.5-3.0, in compliance with the suggested method for determining the UCS and deformability of rock material of International Society of Rock Mechanics (1979). Plastic drain pipe sections are used for making moulds.

The shape of the sample is not a major issue for samples preparation using slow setting resins. Both cube/prism and cylindrical shapes can be prepared and tested individually by mixing resin and mastic at a leisurely pace. The situation becomes more difficult in contrast when preparing the samples from fast setting resins, which typically have a setting time of 15-20 s. Accordingly, the proposed new approach allows several samples to be cast simultaneously from one resin mix batch, reducing sample variability. The method of resin mixing and sample preparation is the focus of discussion in this paper.

CURRENT PRACTICE

The present practice of determining the UCS value of a resin is to cast the resin in the desired shape, depending on one of the standard used and the resin type. For slow and medium setting resin, the current

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practice is to prepare the resin mastic and catalyst mix in a suitable container and then pouring the resin into the mould(s). The mould is made of steel or plastic tubes. Once filled the resin samples are left to harden/cure and then extracted from the moulds. Prior to resin pour, the mould is smeared with inert grease or lubricant sprays to ease sample extraction after casting. Figure 1 shows a typical sample being cast in a plastic mould. The past practice of axially splitting the moulds, especially the cylindrical plastic moulds, is not necessary as the cured or hardened samples are easily extracted from the mould because of the surface lubrication. A simple tapping of the hardened resin sample releases the sample free from the mould. A similar method can be used for cube/prism samples, however the open end side of the cube mould may not be as smooth and flat unless it is covered with a suitable plate so that the cube face is smooth and square. Testing cube samples, which are rough on one side, may not yield uniform test results.

With regard to fast setting resin sample casting, the situation is rather tedious. For 40 mm cubes and 42 mm and greater diameter cylindrical samples casting, a simple manual mixing of resin and mastic in each mould is the preferred practice, however for smaller sized cylindrical moulds of 20 or 30 mm the method of syringe style of suction practice is adopted. The drawback of casting sample by manual mixing and pouring includes:

- The difficulty of removing the air bubbles from the sample, unless the sample is subject to vibration,
- Non uniform composition of the sample mixtures as each sample has to be mixed and poured separately.
- One side of the cube sample will always remain rough, which could eventually influence the test results, and
- Mixing of the resin in the mould may not be uniform, unless the mixer is skilled.

In reality the test results of manually mixed resin samples will have variable values, which may lead to incorrect determination of the value of the sample UCS strength.

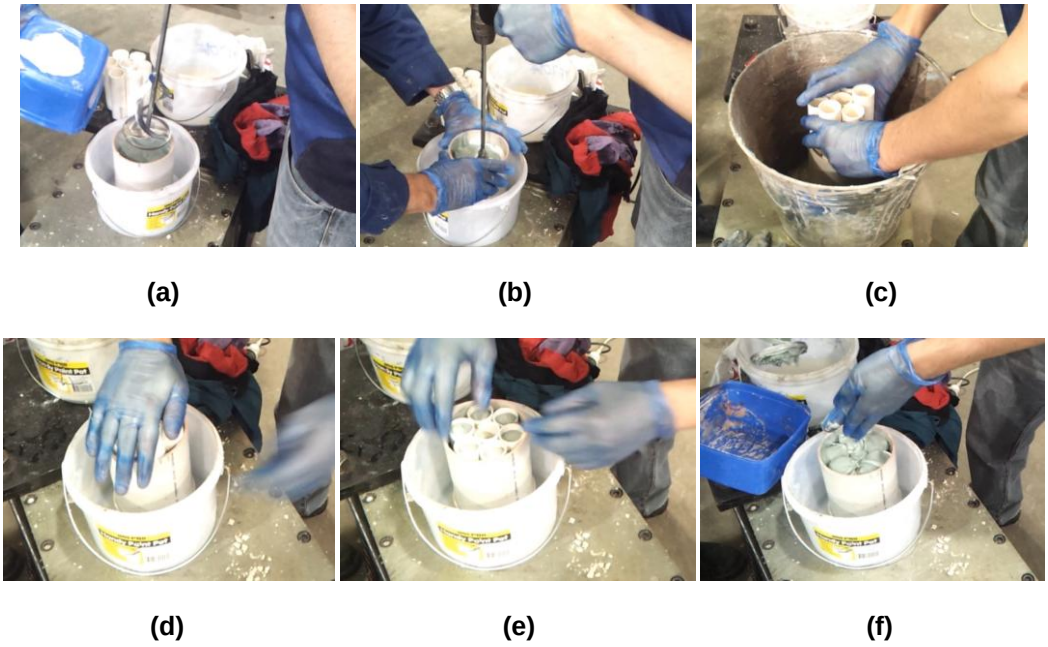
NEW APPROACH

A new approach currently being trialled is to produce several samples from a single resin/mastic mix. This is based on mixing a relatively large quantity of resin /mastic resin in one container mechanically and then has a number of readily prepared moulds forced into the resin mix as a single bunch. Once all the moulds are submerged in the resin mix, it will be allowed to harden which allows the samples to be knocked out of each mould by gently tapping the resin sample out of each mould in the block. Alternatively, the whole resin block is split or broken which allows separating the plastic moulds apart, which is followed by the extraction of the samples out of the plastic moulds. A gentle dowel tapping on each resin sample would facilitate sample extraction from the mould. A paint mixer mounted on to a hand held drill is suitable for resin mixing in the container. Figure 2 (a-f) shows the sequence of resin mixing and sample casting by moulds insertion of he moulds in the container. Ideally up to seven 30 mm diameter moulds can be cast in a 150 mm plastic pipe section.

Figure 1 - Various plastic pipe section moulds and typical moulds arrangement in mixing container. Note two samples in mould

For slow setting resin the insertion of the moulds into the mixed resin is not a major issue. Figure 3 shows a typical block of slow setting resin with 20 mm diameter samples being extracted from it. As shown there were six samples prepared from a single cast block, which was of a sufficient numbers to be tested. Note

that the entire resin sample prepared by moulds forced into the soft resin mix contained a minimum surface roughness as well as being devoid of large air bubbles. Once the samples were extracted from the moulds, their ends were cut perpendicular to the sample axis and then subsequently lapped if necessary and in compliance with the established standard requirements for sample end smoothness.



(a) **(b)** **(c)**

(d) **(e)** **(f)**

Figure 2 - Stages of resin mixing mechanically and sample casting in seven moulds simultaneously

It is worth noting that by forcing moulds into the resin will require some pushing force applied to enable the mould to be forced down the resin mix and this should be done as quickly as possible, because of the limited time available before the resin hardens. Experience will be gained by a few initial trials. Table 1 shows the results of one batch of seven samples being tested for the UCS values and Figure 4 shows post tested failed samples post test. It is clear that the quality of the samples and the results of the test have demonstrated the credibility of the new method of preparing resin samples. This kind of sample casting should also be suitable for cube/prism shapes. The average UCS value of the seven samples tested was 53.16 MPa, with a standard deviation of 0.47 and a coefficient of variation of 0.88%.

Table 1 - Failure load and UCS values of seven samples obtained from one resin/catalyst mix

Sample	Sample age (d)	Sample length (mm)	failure load (kN)	UCS (MPa)
1	4	78.52	36.8	53.88
2	4	78.56	36.1	53.08
3	4	78.29	35.6	52.41
4	4	78.48	36.7	53.38
5	4	78.55	36.3	52.99
6	4	78.12	36.2	53.45
7	4	78.29	36.0	52.91

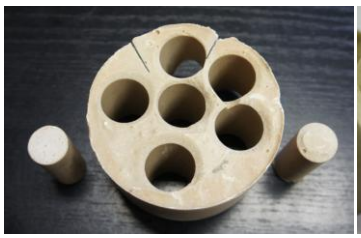


Figure 3 - Mould of slow setting resin and two 20 mm diameter samples

Figure 4 - Two 30 mm diameter tested samples

CONCLUSIONS

The new method of casting multiple samples in bunch represents a convenient method of preparing samples for strength testing. The prepared samples have been found to be of uniform composition and yielded consistent results. The proposed method of casting samples is:

- fast as no additional time is required for repeated casting;
- sample sides are uniform as the moulds are not split axially;
- the method can be applied to cylinder as well as cube sample preparation;
- the methods reduces the formation of voids and the composition of the cast sample is consistent.

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