CONTROLLED LOW-STRENGTH MATERIAL

INTRODUCTION
Controlled Low-Strength Material (CLSM) is a cementitious fill that is in a flowable state at the time of placement and has limited compressive strength to facilitate subsequent excavation.

CLSM is also known as flow-crete and controlled density fill as well as by various proprietary names.

The material has gained appreciable recognition in the USA and Canada as a fill material because of its inherent advantages. These include flowing placement without segregation, self-consolidation, controlled density, controlled strength, ease of excavation, and economy.

Development of CLSM has centred around mixtures using a sand filler. The inter-particle voids are slightly over-filled with a fluid paste composed of cement and water, with the possible addition of fly ash. Components of the paste are varied in quantity to achieve the required performance in terms of strength development, self-consolidation, flow behaviour characteristics, durability, economy and ease of removal.

Overseas experience has shown the sand filler mixtures to have performed well, giving all the properties desired. It may be difficult to achieve satisfactory flowability and there may be severe bleeding in cement-sand slurries – although fly ash can be of assistance in obtaining properties of flowability with reduced bleeding.

From the above description, it can be seen that CLSM is a cementitious material which can be mixed, transported and delivered using normal ready-mix operation techniques and processes. The material does not look like concrete but it performs in a similar manner since it has cementitious properties and, with time, will become quite hard. The latter must be controlled so that it does not become too hard.

As with any concrete, strength is influenced by the quantity of water and cement. Very high water content (300 to 450 kg/m³) and very low cement content (25 to 100 kg/m³) are quite normal for CLSM. Fly ash, sand and, in some cases, coarse aggregates, are selected for their ability to flow rather than for their contribution to strength properties. This implies that sand not suitable for regular concrete may perform quite well in CLSM. Indeed, sands with as much as 30% fines have proven satisfactory.

CONTROLLED LOW-STRENGTH MATERIAL is a cementitious fill that is in a flowable state at the time of placement.
Control of the material on site is best achieved by a flow test. A cylinder or cone is placed on a flat hard surface and filled with the flowable mix. When the mould is lifted, the material will spread on the flat surface. If the measured spread of the CLSM reaches the predetermined distance, the mix is considered to have acceptable flow.

APPLICATIONS
CLSM is ideal for use in any backfilling operation where it is important to minimise settlement or where there is restricted access for compaction equipment. It is also advantageous for backfilling excavations in soils that are prone to collapse when normal compaction equipment is used.

Typical applications are:
- backfilling utility trenches;
- filling abandoned underground structures, e.g. tanks, sewers, tunnels, etc;
- backfilling bridge abutments and retaining walls;
- most situations where soil backfill is required.

Where backfill may have to be excavated at a later date, the strength of CLSM must be limited. Strengths up to 2 MPa at 28 days can generally be excavated using normal construction equipment.

As CLSM is a highly fluid material, consideration must be given to the lateral pressure exerted during placement; lightweight pipes, etc may need to be anchored to prevent flotation.

MIXES
CLSM mixes should be designed for the particular flowing characteristics required as well as the compressive strength necessary.

As indicated previously aggregates are chosen more for their compatibility with the CLSM’s flowing characteristics than their contribution to strength.

A wide range of fine aggregates including sands, gravels and quarry waste material can be used to produce satisfactory CLSM mixes. It is not necessary for aggregate to comply with AS 2758.1–1985. Aggregates should, however, be free of reactive or expansive materials. Coarse aggregates are not normally included in CLSM.

Types GB or GP cement in accordance with AS 3972 can be used in the production of CLSM. Where fly ash is used to improve flowability it should be noted that early strengths will be reduced.

A maximum 28-day strength of 0.5 MPa is suggested where future hand excavation is likely and 1.5–2 MPa for mechanical excavation. Slumps that will suit most applications of CLSM are around 200 mm. Suggested criteria for CLSM mixes are given in Table 1.

### TABLE 1

<table>
<thead>
<tr>
<th>Use/application</th>
<th>Criteria</th>
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<tbody>
<tr>
<td>General purpose</td>
<td>Easy excavation required.</td>
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<tr>
<td>backfill</td>
<td>Early strength not critical.</td>
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<tr>
<td></td>
<td>High degree of flowability.</td>
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<td></td>
<td>28-day strength ≤0.5 MPa.</td>
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<tr>
<td>Roadway trench</td>
<td>High early bearing strength required.</td>
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<tr>
<td>backfill</td>
<td>Good flowability.</td>
</tr>
<tr>
<td></td>
<td>28-day strength 1.5 to 2 MPa.</td>
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<tr>
<td>Structural</td>
<td>Good flowability.</td>
</tr>
<tr>
<td>backfill</td>
<td>28-day strength to engineering requirements.</td>
</tr>
</tbody>
</table>

MIXING AND PLACING
CLSM is best batched and mixed using equipment normally used to mix concrete. It is generally placed direct from agitator trucks but can be placed using chutes, skips or pumps. Where the material is to be pumped, higher cementitious contents may be required. This in turn result in increased strength which may be undesirable if backfill material is likely to be excavated at a later date.

TRENCH BACKFILL
The backfilling of service trenches is an obvious application for CLSM, particularly under paved areas where its hardened state non-settlement properties minimise trench subsidence and hence long-term maintenance costs.

As CLSM does not have to be compacted, the width of the trench is not determined by compaction techniques as with conventional backfill; trenches can therefore often be much narrower, ie just wider than the service to be installed.

No compaction and little, or no, spreading is required. When filling long trenches, moving the discharge point along the trench helps spread the material. The surface may require some minor levelling with a shovel. The trench should be filled to slightly above the bottom of the pavement. This allows for bleed water in the mix, which will rise to the surface, and for some plastic settlements to occur.

If it is not practical to place the pavement immediately, the trench is filled flush with the pavement surface and the CLSM temporarily used as a wearing surface. The CLSM can be later removed to the required depth and the pavement material placed.

Where it is necessary to carry out pavement restoration within 24 hours, mixes giving 28-day strengths of at least 1.5 MPa to 2 MPa should be used. CLSM backfill should be protected from any foot or vehicular traffic until it has hardened.
STRICTURAL BACKFILL
Where CLSM is used as a structural backfill or sub-base, compressive strengths greater than 2 MPa may be required depending on engineering design requirements.

BIBLIOGRAPHY


Further information on good concreting practices can be downloaded from the Cement Concrete and Aggregates Australia website at [www.concrete.net.au](http://www.concrete.net.au).

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