



Denka Power CSA-S Additive **for Shrinkage Compensated Concrete Slabs**

DEMIDEN LIMITED
29 GREY STREET, TAURANGA
PO BOX 704, TAURANGA 3140
NEW ZEALAND
www.demden.co.nz
PHONE +64 7 575 5410
EMAIL info@demden.co.nz

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Guidelines for the specification of DENKA POWER CSA-S for Shrinkage Compensated Concrete Slabs

1. **GENERAL**

All concrete work and reinforcing shall be constructed in accordance with current New Zealand Standards for Concrete Construction. All specifications shall be approved by a professionally qualified engineer.

2. **MATERIALS**

DENKA POWER CSA-S is used as a **replacement** for approximately 5% of the original cement content (**see note on dosage below**). All concrete shall be supplied from a certified plant. High or Special Grade concrete shall be used. The nominal aggregate size shall be 20mm. No chloride shall be added to any mix.

The design engineer is responsible for specifying the required concrete strength. The following specified concrete strength shall be used unless noted otherwise in the Drawings:

DENKA POWER CSA-S concrete 30MPa

DENKA POWER CSA-S concrete shall contain 95 parts of Portland Cement to 5 parts of **DENKA POWER CSA-S** by weight. Batch sizes shall be adjusted to use full 20 kg bags of **DENKA POWER CSA-S** in each mix. The **DENKA POWER CSA-S** shall be delivered dry into the mixer and the batches thoroughly mixed to disperse the **DENKA POWER CSA-S** throughout the concrete.

Alternatively, the **DENKA POWER CSA-S** concrete may be supplied from a certified plant that can accurately weigh the **DENKA POWER CSA-S** out of a separate silo. For this system the target proportions are 95 parts of Portland Cement to 5 parts of **DENKA POWER CSA-S** by weight. However, to allow for weighing discrepancies each batch shall contain not less than 4 parts of **DENKA POWER CSA-S** to 96 parts of Portland Cement, or more than 6 parts of **DENKA POWER CSA-S** to 94 parts of Portland Cement by weight.

The **DENKA POWER CSA-S** concrete shall be mixed rapidly in the truck for an additional 10 minutes at the Plant before being despatched to the site.

No extra water will be added without the approval of the engineer on site.

The recommended water/cement ratio is ≥ 0.45 W/C ratio for shrinkage compensation*.

***A 0.45 W/C ratio or greater is suggested from test data using one type of NZ cement. ≥ 0.4 W/C is probably acceptable, depending on the cement source. Testing to confirm strength of the specific concrete mix is recommended.**

Maximum Dose Quantities: Depending on the cement content of the mix, the dose of Denka Power CSA-S will typically be 15 to 20kg/m³. For mixes with original cement contents greater than 400kg/m³, it is generally recommended that Denka Power CSA-S is dosed at a maximum of 20kg/m³.

The information on maximum dose is based on data from Denka, Japan, and testing performed by Cement Research Ltd, New Zealand.

Note on Mixing: 10 minutes rapid mixing in the truck is essential to ensure Denka Power CSA-S is uniformly dispersed. Any reduction in this mixing time increases the risk of small pockets of Denka Power CSA-S being present and the formation of small “pop outs” on the slab surface.

3. **REINFORCING**

Reinforcing bars for the **DENKA POWER CSA-S** concrete slabs shall be placed in three layers, with half the bars in one direction in each of the top and bottom layers (staggered to achieve the required spacing), and all the bars in the other direction in the middle layer, so that the centroid of the reinforcing in each direction is in the centre of the slab.

Guidelines for reinforcing ratios for **DENKA POWER CSA-S** concrete slabs are available from Demden Limited.

4. **FORMWORK**

Plywood or pine boxing shall be used for all formwork unless approved by the Engineer or detailed otherwise in the Drawings.

All penetrations, nibs, chases, fixings, sleeves, pipes, conduits, bolts, starter bars, etc. as detailed in the Drawings and as necessary to complete the work shall be accurately positioned and securely held in place.

5. **PLACING, COMPACTING AND FINISHING CONCRETE**

The contractor shall ensure that the **DENKA POWER CSA-S** concrete can be delivered with minimal risk of delays. This may require pours to begin during the night.

The concrete must be protected during adverse conditions i.e. use aliphatic alcohol to protect the surface from drying in hot and/or windy conditions.

Immediately prior to placing concrete, all dirt, sawdust, shavings and any other refuse shall be removed from inside the formwork, and all reinforcing shall be clean and free from all loose mill scale, dirt, dust, loose rust, coatings such as oil and paint, or anything which will prevent bonding to the concrete.

The concrete shall be placed and compacted to produce a homogeneous mass which completely fills all the space, including all corners and completely surrounds all reinforcement. The use of vibrators or other compacting equipment shall not cause displacement of the reinforcing or embedded fixtures, nor disturb the formwork.

Concrete finishers should note that typically **DENKA POWER CSA-S** concrete leaves little or no excess water to bleed out onto the surface. Therefore, the appearance of bleed water on the surface cannot be relied upon as an indicator that the concrete is about ready for finishing.

Floor slabs shall be power floated to give a U3 finish.

6. **CURING OF CONCRETE**

After the concrete has set sufficiently its exposed surfaces shall be cured by applying water continuously for a minimum of ten days. Alternatively, clear polythene sheets may be used to cover the pre-wetted concrete slab for ten days and the entire slab shall be kept wet at all times beneath the polythene by supplying water under the sheets as necessary. Care should be taken to avoid wind blowing the polythene sheets off the slab, as this may result in rapid and uneven drying of the slab surface. Curing blankets can also be used instead of polythene.

Do not use black polythene as dry areas cannot be identified and slabs exposed to direct sunlight may be subject to significant temperature change.

Addition of **DENKA POWER CSA-S** can compound the risk DEF (Delayed Ettringite Formation) so under no circumstances should the concrete be allowed to exceed 60°C during the cure period.

7. **CONSTRUCTION JOINTS**

If not shown in the Drawings construction joints shall be located and built to details as directed or approved by the Engineer.

Joint sealing is generally left as long as possible and is often not performed until the slab is 1 year old. Practical issues sometimes dictate earlier sealing and therefore there is risk of shrinkage exceeding the capacity of the jointing material. Larger slabs can exacerbate the situation. This statement applies to concrete whether or not it contains **DENKA POWER CSA-S**. The use of **DENKA POWER CSA-S** merely alters the point from which shrinkage occurs. The manufacturer of the joint sealing material should be consulted.

8. **CONSTRUCTION OF SLABS ON GRADE**

The surface beneath slabs shall be smooth and even with no loose particles or protrusions that could damage the DPC.

A dampproof course (DPC) consisting of 2 layers of 0.25mm polythene shall be laid continuously under the floor slab with 150mm laps. Any perforations or damage to the DPC shall be repaired before concrete is poured over. The DPC layer shall continue through under the boxing and shall not be lapped up over any formwork.

The **DENKA POWER CSA-S** slabs need to be isolated, so they are not constrained (no reinforcing to continue into the **DENKA POWER CSA-S** slab).

All re-entrant corners shall have diagonal reinforcing placed across each corner i.e. 2 x D12.

Any steel angles used on the edges of the slabs should be welded (including slab corners) to be continuous along the edge of the slab or alternatively the shortest practical lengths should be used to minimise the risk of restraint and crack inducement.

Any dowel system which allows for the slab to move horizontally in both directions would be acceptable provided the total expected movement (expansion and subsequent shrinkage) of the **DENKA POWER CSA-S** slab is allowed for. The larger the slab dimensions, the larger the total movement. High movement dowel systems are available, and the manufacturers should be contacted directly for their recommendations. Ground beams are also recommended under movement joints.

The **DENKA POWER CSA-S** concrete slabs shall be poured to have at least two edges free to allow the concrete slabs to expand without obstruction or confinement. Adjacent slabs shall be poured not less than three days apart.

Where slabs are cast against restraints (e.g. walls, footings) a 10mm (or thicker as required for slab dimension and expansion) thick polystyrene layer shall be placed against the restraints and removed a maximum of 24 hours after the slab is poured to allow expansion to take place. Columns shall be isolated from the **DENKA POWER CSA-S** concrete slabs. Compressible foam, which does not need to be removed, can be used instead of polystyrene.

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Recommendations, suggestions or statements made by Demden Limited are intended for the assistance of our customers. They are based upon our experience and judgement but must not be regarded as amounting to a legal warranty or as involving any liability on our part.

Notes for Concrete Companies and Placers

Denka Power CSA-S is widely used in concrete to create large slabs with minimum joints. It is important to understand how Denka Power CSA-S Concrete works, and the special procedures and precautions that are required.

Denka Power CSA-S can also be used in general construction, at lower dose rates, however that is not specifically covered in this document. The same general precautions for mixing and placing will apply.

Structure Design

These will normally be taken care of by the structure designers, but there are some things which can impact on programme that it is worthwhile to be aware of:

Shrinkage compensated concrete works by expanding to offset the natural shrinkage of the concrete. The expansion occurs early in the life of the concrete, the shrinkage over a longer period. The design must allow space to accommodate the expansion before the shrinkage occurs. For this reason, slabs must be free of keys or other restraints that will limit expansion. The concrete must be able to expand on at least two edges. Pouring adjacent slabs is not permitted for several days following pouring of the first slab.

In some instances, Denka Power CSA-S shrinkage compensating concrete is used in infill situations. The designer needs to consider the forces involved, and whether the expansion will push apart the restraining elements.

Reinforcement is an important aspect of the design of shrinkage compensating concrete as it is placed into tension as the slab expands, and then pulls the slab back into position as it shrinks. The design engineer will specify the amount of reinforcement required, and the amount will normally be greater than a standard concrete slab. Reinforcing must be placed in two directions so that it restrains the slab and placement details are provided by the design engineer. Special detailing and isolation is required around columns. Designers usually specify 2 layers of DPC.

These provisions can mean truck access for pouring is limited, and therefore placing may be slower.

Mix Design

Maximum Dose Quantities: Depending on the cement content of the mix, the dose of Denka Power CSA-S will typically be 15 to 20kg/m³. For mixes with original cement contents greater than 400kg/m³, it is recommended that Denka Power CSA-S is dosed at a maximum of 20kg/m³. Higher dose rates may result in expansion in excess of what is required for shrinkage compensation and may result in lower compressive strength. Consult the Denka Power CSA-S supplier regarding high dose rates.

The information on maximum dose is based on data from Denka, Japan, and testing performed by Cement Research Ltd, New Zealand.

The mix design should be reviewed for each job, i.e. existing designs should not be recycled without reference to the Plant Engineer. This should normally be done at the pricing stage.

The product supplier's instructions for dosage and cement replacement need to be followed, and if not compatible with the specification reconciled with the specification writer.

All concrete for any pour must use the same aggregate, and it is very desirable to supply from one plant.

Air content should be minimised, particularly if superplasticiser is used. Some concrete placers prefer to have 100mm plus slump, without superplasticiser and this shall be discussed with the design engineer. Some concrete companies recommend not having AEA in Denka Power CSA-S concrete mixes, as increases chance of delamination and reduces strength, and this shall be discussed with the design engineer.

No chlorides shall be used.

Avoid the use of lignosulphonates and naphthalene sulphate water reducers and superplasticisers.

A 0.45 W/C ratio or greater is suggested from test data using one type of NZ cement. ≥ 0.4 W/C is probably acceptable, depending on the cement source.

Testing to confirm strength of the specific concrete mix is recommended.

Mixes containing ground granulated blast furnace slag should have a maximum dose of 3% Denka Power CSA-S.

The mix design must be adjusted to use a full number of bags for each batch, i.e. part bags should not be used. This will mean an odd load size and trucks running at less than capacity.

A trial mix is recommended to get the water demand and slump correct prior to the job pour. Blocks should be taken to confirm strength.

Production

To ensure the product is fully dispersed, mixing times shall include an additional 10 minutes for a full load in a truck or similar type mixer. Please note it is critical that trucks do not leave plant without full mix time of 10 minutes rapid mixing – slow mixing during transit is not acceptable. If mixing is not adequate, there is a high risk that “pop outs” will be seen on the surface of the concrete after curing.

No other concrete can be mixed in the mixer while a job is in progress unless the mixer is very thoroughly cleaned.

At the end of the job the mixer, loading hopper etc, and all trucks, charge hoppers, and chutes etc used must be given a very thorough clean. The reason for this is that if any small amounts

of the shrinkage compensating product remain and then subsequently get into other concrete it is likely to spall the surface as it expands.

Placing

Mixes containing shrinkage compensating additives do not bleed as freely as ordinary concrete. This seems particularly so when superplasticisers or MRWRDAs are used, and this can mislead placers to get on to finishing too early. Cracking, delamination, and burning are all problems that may occur if the finishing is not done properly.

Discuss finishing times with the placer — make sure the placer is aware of the reduced bleeding. Make sure the placer also understands that the surface should not be overworked.

Maintain a steady even flow of concrete to the job consistent with the placer's finishing ability.

Superplasticisers are difficult to disperse in mixed low slump concrete. For this reason, and to maintain the consistency of bleed rate, make any on-site slump adjustments with water.

Particular attention also needs to be paid to curing, which should be for a minimum of 10 days and in accordance with the Denka Power CSA-S supplier's guidelines.

Denka Mix Batching Sequence*

1. Load Denka Power CSA-S additive into the empty concrete truck or central mixer. Add Denka Power CSA-S into the mixer first or spread over coarse aggregate on the conveyer belt (if access allows). Adjust batch volume to use only whole bags of Denka.
2. Ensure that Denka Power CSA-S powder is not hung up on the fins.
3. Close, bundle and tie empty Denka bags and write batch ticket number on bundle. Store in workshop. Keep empty bags for minimum 3 days after pour date.
4. Load 80% of batch water and 100% of admixtures into truck.
5. Load 100% of aggregate into truck once 70% of water is loaded.
6. Load 100% of cement into truck once 80% of batch water and 20% of aggregate is loaded.
7. Load final 20% of batch water into truck once 100% of cement loaded.
8. Add trim water to truck to achieve desired slump.
9. **Mix concrete thoroughly and then stand the trucks aside and mix at full rotation speed for a further 10 minutes before despatching to the site.**
10. Check mix for lumps before truck leaves plant.

*This sequence is a recommendation and each plant must determine the best method to ensure complete dispersion of Denka Power CSA-S throughout the mix.

CAUTION

Denka Power CSA-S must never be added last to the concrete mixer

Please Note: These bags are **NOT** soluble and must **NOT** be added to the mixer. The bags must be split and the contents added to the mixer in a method that avoids any clumping of the Denka Power CSA-S powder.