Teagasc
Agriculture and Food Development Authority

FARM CONCRETE

April 2017

S.100 – Farm Concrete

Every year, Irish farmers undertake a large amount of building work ranging from major new jobs to extensions to existing buildings and effluent tanks and minor improvements around the farm. Under the Rural Development Programme 2014-2020, it is likely that many farmers will avail of grant assistance for investment in farm buildings under the Targeted Agricultural Modernisation Scheme (TAMS II).

There are a few simple rules which if carefully followed, will ensure that the concrete used in the construction of these farm buildings is of good quality and will lead to a lifetime of trouble-free service. The 'design life', as recommended by European design standards, for agricultural buildings is 25 years.

S.100

S.100 is the minimum concrete specification required for the construction of agricultural structures in Ireland for compliance with the EU Nitrates Directive. The specification was revised by the Department of Agriculture, Food & the Marine in 2015.

There are two grades of concrete provided for under S.100 and these are the minimum legal mixes required by the Department of Agriculture Food & the Marine for concrete used in structures that retain silage, silage effluent, slurry, farm yard manure or soiled water.

The first grade, S.100 (Mix A), must be used for concrete for silage pits and walls, silage aprons and silage effluent channels and stores. The second grade, S.100 (Mix B) must be used for concrete for all other purposes on the farm.

S.100 (Mix A)

Mix Reference	S.100 (Mix A)	Used in:
Strength	45N/mm^2 (Strength Class C35/45)	Silage pit walls
Minimum Cement Content	360 kg/m^3	Silage slabs
Maximum Water / Cement Ratio	0.5	Silage aprons
Slump Class	S2 or S3	Silage effluent channels
Maximum Size of Aggregate	20mm	Purpose built silage effluent stores
Exposure Classes (25 year design life)	XA3, XC4, XF3	

S.100 (Mix B)

S.100 (Mix B) is the minimum grade of concrete used for all other farm structures including slurry tanks to which silage effluent may be directed. The key characteristics of S.100 (Mix B) are as follows:

Mix Reference	S.100 (Mix B)	Used in:
Strength	37N/mm^2 (Strength Class C30/37)	Slurry tanks to which silage effluent may be directed.
Minimum Cement Content	310 kg/m^3	
Maximum Water / Cement Ratio	0.55	All other farm structures except slabs exposed to freeze / thaw action (XF3 applies).
Slump Class	S2 or S3	
Maximum Size of Aggregate	20mm	
Exposure Classes (25 year design life)	XA1, XC4, XF2	

Note: In the case of exposed yard slabs where freeze / thaw action is a concern, S.100 Mix A or S.100 Mix B containing 3.5% minimum air entrainment must be used.

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Set for life

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Recent Changes to S.100

The 2015 revision to S.100 references the potential use of additional materials in the manufacture of the concrete as follows:

- A range of cement types (CEM I, CEM II/A CEM III/A) are permitted for use, along with additional cementitious materials (Ground Granulated Blastfurnace Slag, Pulverised Fly Ash, Microsilica) which can be combined with cement. These materials require specialist knowledge, as well as guidance on use and the concrete manufacturer should be consulted for advice.
- The use of polypropylene fibres is now referenced in building specifications such as S.101 (Minimum Specifications for the Structure of Agricultural Buildings) & S.123 (Bovine Livestock Units and Reinforced Tanks). These fibres can help reduce the risk of plastic cracking in slabs and thus improve surface durability. However, they are not a substitute for reinforcement. They do not change the need for proper curing. Discussion with the concrete manufacturer is required for their inclusion in the mix.
- Self-Compacting Concrete (SCC) is permitted for use in vertical elements only. This type of concrete should be supplied by a manufacturer with experience in its production and use. A contractor must take particular care in its use in relation to higher than normal hydrostatic pressure on shutters and sealing requirements to prevent leakage at joints. Guidance should be obtained on its use on site.

Specifying and ordering S.100 concrete

As mentioned on page 1, two mixes are approved for use in farm construction, depending on the type of structure.

- **S.100 (Mix A)** is for silage pit walls, silage slabs, silage aprons and silage effluent channels and stores. The concrete for this use should be ordered by specifying **"S.100 (Mix A)"** or alternatively by requesting **"45N concrete with 360kg minimum cement content, 0.50 maximum water cement ratio, and slump class S2 or S3, certified to I.S. EN 206 for use to Specification S.100".**
- **S.100 (Mix B)** is for all other structures, including slurry tanks which may also hold silage effluent. The concrete for this use should be ordered by specifying **"S.100 (Mix B)"** or alternatively by requesting **"37N concrete, with 310kg minimum cement content, 0.55 maximum water cement ratio, and slump class S2 or S3, certified to I.S. EN 206 for use to Specification S.100".**

The workability to be specified for either mix depends on the element being constructed and the method of placing. The contractor should decide on the workability level required. Two slump classes are permitted in S.100:

- **S2:** Range 50 – 90 mm slump;
- **S3:** Range 100 – 150 mm slump;

These slump classes obviously do not apply if self-compacting concrete is being used (see above). Forms to assist specifying/ordering concrete for both mixes are attached to S.100.

It is important that accurate quantities are ordered for the particular element being constructed. This will enable the manufacturer to optimize loads. If the total quantity required exceeds the typical load of 7m^3, it is important that the last load ordered will complete the pour and ensure that a small quantity is not outstanding.

The rate of placing and compacting/finishing should be estimated and the delivery rate matched to this. It is important to avoid 'cold joints' between loads being placed, due to large time gaps in loads delivered. It is equally important that concrete trucks are not waiting for long periods on site, as the workability of the concrete will decrease.

Concrete Supplier Certification

All concrete used for farm structures must be produced by a concrete manufacturer independently certified to produce in accordance with the standard I.S. EN 206. For the purpose of claiming grant payment from the Department of Agriculture, Food & the Marine, a copy of the concrete manufacturer's annual I.S. EN 206 certificate and a copy of the Concrete Manufacturers Specification Certificate which gives details of all concrete deliveries, must be submitted with each grant claim. Farmers and farm contractors should ensure in advance of construction that concrete suppliers are able to produce both of these certificates.

Site Access and Transport

Safe and reliable access must be provided for deliveries of concrete. A fully loaded, four-axle concrete truck requires a sound base on which to travel, as it can weigh up to 32 tonnes. Access around structures must be available to manoeuvre the truck and its delivery chute. Concrete pumps or truck-mounted conveyors can be used to place concrete at longer distances or in locations that are difficult to access. However, care needs to be exercised in their use and overhead access should not be compromised by other structures or power lines. Suitable lighting should be available if long pours are envisaged.

Preparation for elements being cast should be completed in good time before delivery as follows:

- Shutters should be fully erected and supported and reinforcement fixed.
- Slab bases should be prepared with compacted hardcore and polythene (if specified/required).
- A pre-pour check should be completed to ensure the correct number of rebars are included, the specified cover to any reinforcement is correct and there is no debris in the shutter.

Site Workmanship

The following aspects of site workmanship are vital in ensuring that the concrete can perform its function for the designed lifetime.

Foundations & Hardcore:

Concrete slabs should only be poured on a solid, properly constructed foundation. The work area should be stripped to provide a suitably stable base, backfilled with hardcore and properly compacted. In cases where aggregate (fill) is purchased, it shall be certified to EN 13242 and meet the requirements of Annex E of SR21. It is important when ordering aggregate (fill) that this specification is clearly communicated to the supplier.

Addition of Water:

The concrete should arrive at the site in full compliance with the specification. This includes the workability (or slump) level.

If concrete with a higher slump is required, order S3 rather than S2 slump class. The addition of water on site is forbidden under the concrete standard (I.S. EN 206). Extra water will reduce strength and durability and increase the risk of cracking, surface damage and failure. If added at the request of site staff, the concrete becomes 'non-conforming' and not in compliance with the specification and will be so recorded.

Technical staff of the concrete manufacturer are permitted to authorise addition of water (or plasticiser) on site, only if the mix still complies with the limiting values and cubes are taken after such addition. Any water (or admixture) added on site must be recorded on the delivery docket.

Placing:
Concrete should be placed as close to its final position as possible. For deep pours, concrete should be placed in layers of no more than 600 mm. Dropping concrete from heights of over 3 metres should be avoided unless a tremie pipe is used. This prevents segregation of the mix and splashing off the reinforcement. For long walls, the concrete should be placed at a number of locations along the shutter. The concrete should not be moved any significant distance horizontally by use of the poker vibrator. Over-reaching with equipment should be avoided. Pumps can be used for difficult locations or to permit greater reach from the truck position.

Compaction:
Fresh concrete needs to be compacted otherwise the strength and durability of the concrete is reduced. Compaction should follow-on shortly after placing. Vibrating screeds are useful and efficient in compacting concrete in slabs up to 150mm. For deeper slabs and bases and for all walls, poker vibrators should be used to properly compact the concrete. Pokers should be not less than 50mm in diameter and should be inserted at a maximum spacing of 400mm. In walls, each layer should be 'stitched in' to the one beneath using the poker to penetrate at least 100mm into the lower layer. Touching the formwork or reinforcement with the poker vibrator should be avoided.

Finishing:
Surface finishes to slabs, yards and walls should be suitable for purpose. Silage slabs can have a smooth trowelled finish as once properly cured, this will ensure a hard dense surface to resist attack from silage effluent (power trowelling gives an even denser finish). A brush finish may be more appropriate for general yard slabs to provide greater surface grip for machinery or animals under wet conditions. The surface finish to walls depends on the formwork used. The formwork face should be smooth, free of significant defects and be treated with release agent before casting. High quality surface finishes to vertical elements are not normally required on farms, but can be specified if special circumstances exist.

Curing

Concrete curing is the prevention of moisture loss. Concrete is fit for purpose only when proper curing procedures are employed and the structure is not put into use until an adequate curing time has elapsed. Concrete needs to be protected to prevent moisture loss and the effects of harmful weather and damage, especially for the first 7 days after placing. The longer the concrete is allowed to cure before use, the greater its durability and service life will be. The lack of good curing can result in poor surface quality, loss of strength and potential plastic shrinkage cracking. S.100 and other farm specifications emphasise that concrete is fit for purpose only if proper curing procedures are adhered to and the structure is not put into service for at least 28 days. In the case of silage structures, it is especially beneficial if the concrete is let mature for a longer period before it is exposed to silage effluent.

Curing involves keeping the exposed surfaces moist in order to minimise the risk of plastic shrinkage cracking at the setting stage and ensuring good strength development and durability, particularly in the surface layer from the ongoing hydration of the cement. There are a number of methods of achieving proper curing for exposed surfaces including:

- Spraying the surface continuously with water or mist spray, once set.
- Covering the surface with polythene before surface moisture is lost. The polythene must be firmly fixed to prevent a 'wind tunnel' effect.
- Placing wet coverings on the surface and preventing the coverings from drying out.
- Application of a suitable curing compound. These cannot be applied until almost all of the bleed water has evaporated. The curing compound may need to be replenished after a few days, depending on its efficiency.
- For slabs or floors exposed to drying winds, a wind break may be required to prevent severe loss of moisture.
- For formed surfaces, retention of the formwork in place prevents moisture loss.

Formed faces are usually required to receive a curing compound immediately after stripping, especially if the forms are removed between 16 and 24 hours after casting. Curing periods vary depending on weather conditions and the type of cement used in the mix.

Surface Protection:

Concrete needs to be protected from the harmful effects of extreme weather. In particular, concrete must be protected from freezing in its early life before it has achieved sufficient strength.

Freezing conditions can result in severe disruption of the concrete matrix caused by the water in the concrete turning to ice, leading to internal expansion. Typical industry guidance is not to place concrete when temperatures are below 5°C and falling. However, placing is possible at temperatures of above 3°C and rising. Concrete should never be placed on frozen ground or formwork. With low ambient temperatures, or if frost is forecast, exposed concrete surfaces must be covered with an insulating material (e.g. frost blanket for slabs) which retains the heat generated from cement hydration. Even in 'normal' weather, surfaces of deeper slabs may need insulation as cold nights can give rise to large temperature differentials across the concrete section, which could cause cracking. Formwork made from wood usually provides sufficient protection to concrete. In extremely low temperatures, additional insulation may be required. In addition, freshly laid concrete may require protective barriers to avoid damage to corners or vulnerable parts.

In hot weather, fresh concrete can have a shorter working life which causes difficulties in transport, placing and finishing. Concrete placed under high temperatures will set quicker and can, therefore require more rapid finishing. Ambient air

temperatures of 20°C and greater, allied to low humidity and drying winds, require more efficient curing regimes to be employed. The use of cold water can cool the surface layer too quickly resulting in cracking (also known as 'thermal shock'). Rapid drops in the temperature of exposed concrete surfaces arising when concrete is placed on a hot day followed by a cool night can give rise to large thermal gradients with a resulting risk of cracking. The concrete standard I.S. EN 206 requires that the temperature of concrete on delivery shall not be more than 30°C. In hot weather, transport delays should be minimised and the concrete should be placed, compacted and finished as soon as possible. Concrete slabs can be shaded from solar gain and drying winds by the use of special mats, curing membranes or sheets. Dry and/or hot absorbent surfaces should be moistened sufficiently, before placing concrete in contact with them. Existing concrete surfaces, against which concrete is to be placed, should be clean, free of dust and also moistened sufficiently.

Joints

Joints are planned breaks in larger concrete elements which allow movement between the sections. These can be either construction joints or designed joints. Some joints require load transfer arrangements (e.g. dowel bars or reinforcement) while others (e.g. in tanks) may require waterbar to prevent leakage. Recommendations for joint formation and sealing can be found in Department of Agriculture, Food & the Marine specifications such as S.123, S.129 etc.

Construction joints, such as in wall kickers, are formed by the placement of concrete to the top of the kicker form. The top surface has then to be cleaned of laitance (i.e. thin weak layer of water, cement and fine sand) and roughened before subsequent casting. This could be done by washing soon after setting or scabbling. With planned construction joints in walls it is necessary to provide stop-ends, these are often made from timber. These must be gently removed when the concrete has hardened. To achieve good bond between casts, the surface is usually roughened to expose the coarse aggregate. This can be achieved by scabbling. Expanded mesh can be used as a suitable stop-end and usually requires little further remedial work. Stop-ends must be constructed to permit the reinforcement to continue on into the next pour. These can be difficult to seal fully against grout loss.

Designed joints are planned breaks in concrete which allow it to expand or contract without cracking in the sections. They are also used to isolate sections from other 'fixed' elements (e.g. around columns or bases). Such joints are referenced and specified in Department of Agriculture, Food & the Marine specifications.

Joints in slabs can be formed before casting, or sawn later in the young concrete. Sawn joints are usually cut when the concrete has gained sufficient strength so that the coarse aggregate is not debonded from the concrete when sawing. For medium strength concrete this is usually between 16 and 30 hours after casting under normal conditions. The depth of cut for sawn joints should be between 25% and 33% of the depth of the slab. This is sufficient to induce a full depth crack, if stresses are high enough at that point (not all sawn joints will show full depth cracks).

Construction Details & Specifications

Department of Agriculture, Food & the Marine specifications provide requirements and guidance on reinforcement, formwork, joints and good construction practice. Minimum dimensions are given for various elements in these specifications in order to ensure sufficient strength and load capacity, as well as durability. Some of the more important specifications are listed at the end of this publication. These requirements should be followed to ensure that the structure is properly constructed to withstand the necessary loads and that it will be durable throughout its design lifetime. For example, the correct concrete cover to steel must be ensured so that corrosion of the bars is prevented.

Requirements for silage effluent drainage channels are outlined in S.120 and S.128. It is important that effluent channels are constructed to the highest quality as they carry the largest volume of silage effluent and are prone to greater attack from the effluent. It is also important that they remain unblocked during use. The use of a perforated pipe can be used to ensure easy and quick removal of effluent.

Health & Safety

The Health & Safety Authority has produced an information sheet entitled a "A Guide for Clients involved in Construction Projects". This information sheet is also available on the Department of Agriculture, Food & the Marine's website and outlines in practical terms what is legally required of clients commissioning construction work under the Safety Health and Welfare at Work (Construction) Regulations. Such requirements may include the appointment of a Project Supervisor for the Design Process (PSDP) and a Project Supervisor for the Construction Stage (PSCS) before construction begins and notification of the Health & Safety Authority, depending on the duration of the construction works.

Working with concrete involves certain hazards. It is important to use the correct PPE at all times and to refer to the manufacturers material safety data sheet (SDS) for information.

Department of Agriculture, Food & the Marine Specifications

There is a list of Department of Agriculture, Food & the Marine specifications for farm buildings and structures available on the Department's website. Some of the more important specifications are:

S.101	Minimum Specifications for the Structure of Agricultural Buildings
S.120	Concrete Walled Silos
S.122	Minimum Specification for Proprietary Over ground Circular Slurry / Effluent Stores
S.123	Bovine Livestock Units and Reinforced Tanks
S.123A	Extension of Existing Concrete Tanks
S.128	Concrete Silage Bases
S.128A	Resurfacing of silo floors
S.129	Minimum Specification for Farmyard Drainage, Concrete Yards and Roads