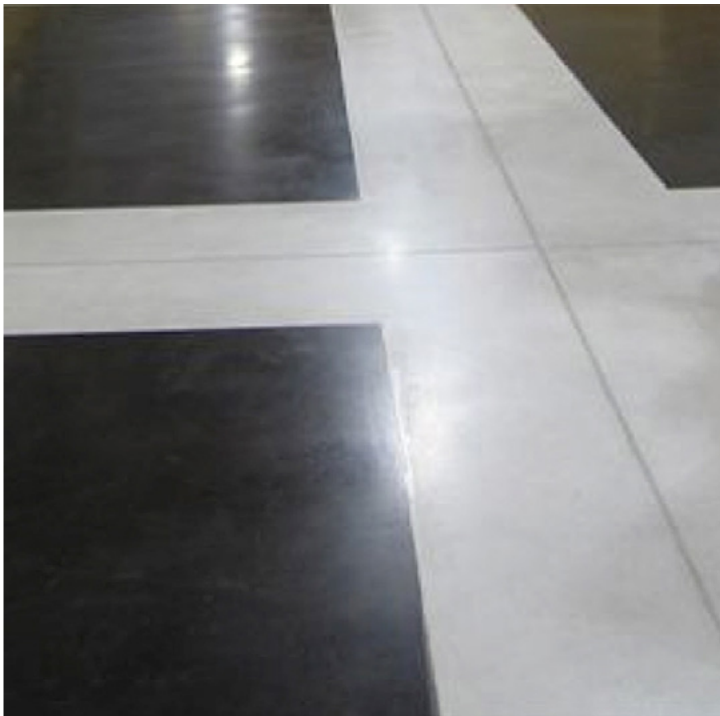
Specifier's Guide to Interior Concrete Floors

CONCRETE FLOOR CONTRACTORS ASSOCIATION OF CANADA • 2016

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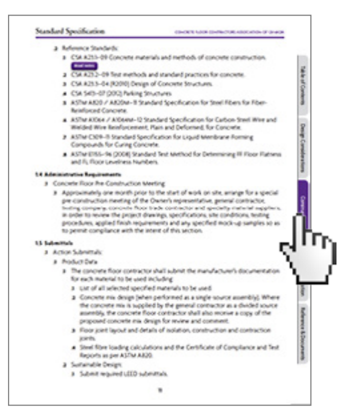

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Foreword

Concrete floor trade work in Canada currently varies significantly in quality due to divided responsibilities, poor understanding of national standards, inconsistent compliance with specification requirements, inadequate technical knowledge, variable field skills, lack of inspection, and the absence of any formal requirement to commit to quality.

The Concrete Floor Contractors Association (CFCA) was founded in Toronto in 1972 by leading members of the concrete floor trade in an effort to organize, standardize, and promote high quality concrete flooring. Since its creation, CFCA members have evolved from their "cement finishing" roots to include all aspects of concrete floor construction. Modern CFCA trade contractors offer complete concrete floor solutions to meet any need.

It is the intent of this guide to assist architects and engineers in defining concrete floors in standardized terms, such that the industry can consistently meet the needs of its clients. This document also aims to further define the responsibilities for CFCA members in order to produce high quality work. While this guide provides general recommendations, it remains the responsibility of the designer to consider and specify concrete floors that satisfy the particular needs of their clients. This guide is intended for use by professional architects, engineers, interior designers and specification writers – it is not a substitute for such professional advice. The CFCA extends its full assistance in supporting its specifiers in conjunction with the information in this guide.

Although there are many available sources of information on concrete flooring, this remains the only guide in Canada that has been written by concrete floor trade contractors for specifiers. The standard concrete floor specification included in this guide has added commentary which we hope you will find informative and useful.

It is through the continuing support of specifiers, that the vision of consistent, high quality results are achieved. Specifiers who prequalify members of the CFCA facilitate our continuing efforts to promote standardization and quality within the concrete floor industry across Canada.

Your feedback to this guide is welcome as it helps the industry evolve to meet the demands of building owners, specifiers and users.

Please call, **e-mail**, or visit us online at **www.concretefloors.ca**

Concrete Floor Contractors Association

Note: The use of the term "Specifiers", in the context of this document, is synonymous with architects, engineers, interior designers and specification writers as representatives of building owners.

Design Considerations

The "Concrete Floor" Specification: Section 03 35 00

Specifications commonly divide concrete floor requirements into three "concrete" sections; "Cast-in-place Concrete", "Concrete Finishing", and "Concrete Floor Hardening". Conflicts often occur due to the variation of the requirements of each section, leading to problems and to potentially lower quality results. A separate "Concrete Floor" specification section is required in Division 3 to remedy this.

Included in this guide is a concrete floor specification section template for concrete floors on grade, metal deck and bonded concrete toppings. Specifiers are encouraged to adopt this specification section as a template for high-quality concrete floor construction.

It is essential that the required concrete floor tolerances from Division 9 be placed within the concrete floor specification section 03 35 00. Tolerances listed in other specification divisions are not generally referred to by concrete floor contractors when tendering or constructing concrete floors.

An editable version of the specification is available online: Download document

Canadian Standards

All specifications must reference compliance with the national Canadian standard "CSA A23.1 Materials and Methods of Concrete Construction". This defines several mandatory requirements which are essential for obtaining high-quality results. All CFCA members understand and comply with these standard requirements.

Other CSA standards for reference:

- CSA A23.2–14 "Test Methods and Standard Practices for Concrete"
- CSA A23.3–14 "Design of Concrete Structures"
- CSA S413–14 "Parking Structures"

Specifiers must not reference "guides" within specifications, such as ACI 302 – they do not stipulate mandatory requirements for compliance, but do offer a number of alternatives to assist in decision making.

Specification of Responsibilities

There are two approaches to constructing concrete floors. The first being the traditional "Divided-Source" approach, where the concrete floor contractor performs only a part of the work, such as placing and finishing. The second is the "Single-Source" full responsibility approach, where the concrete floor contractor organizes, plans and supplies all labour and concrete materials to construct the entire concrete floor assembly.

Figure 1: Divided-Source Approach

For the traditional "Divided-Source" approach to constructing concrete floors, several unrelated parties come together on the day of the concrete placement, with potentially varying commitments to quality and coordinated efforts. The division of responsibility, or the supply of materials and workmanship by these parties can promote non-conformance, material substitutions, omissions, and ultimately low-quality results. The divided scope approach embraces a philosophy of "doing what you are told", be that correct or otherwise.

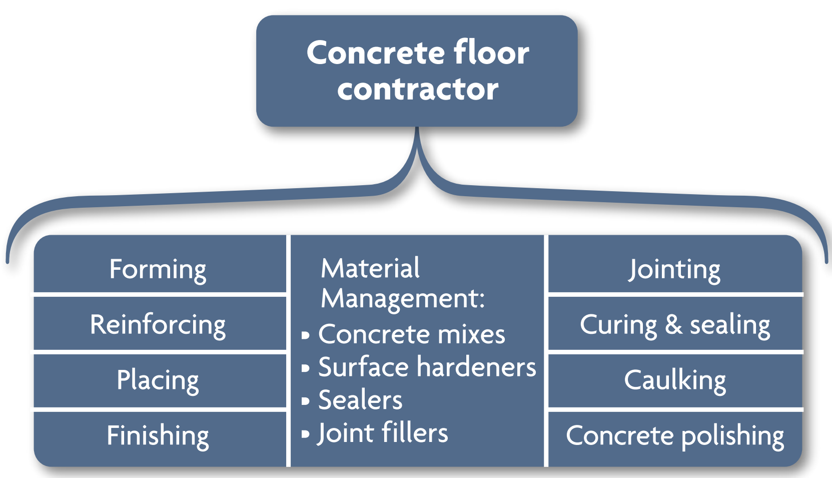

Figure 2: Single-Source Full Responsibility Approach

For the "Single-Source" approach, all concrete floor materials and workmanship are coordinated by a qualified concrete floor contractor, in order to produce optimal results. While the basis for this approach remains prescriptive, inclusion of the full scope of concrete floor assembly under the care of a knowledgeable and experienced concrete floor contractor also adds an element of performance planning.

For the highest quality results, all materials and workmanship should be coordinated and managed by a single competent source – an experienced and knowledgeable concrete floor trade contractor. To achieve consistent, higher quality results, the concrete floor contractor needs to embrace responsibility for the complete orchestration of all materials and workmanship.

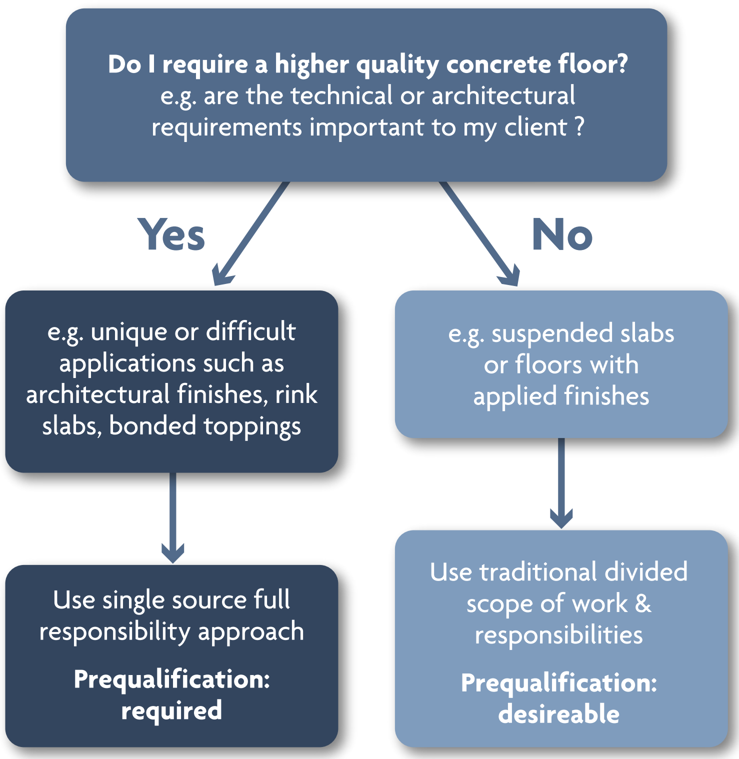

Figure 3: Responsibilities Decision Tree

Pre-qualification

While much time is spent assessing materials in specifications, less time is spent pre-qualifying workmanship or defining the responsibilities of various parties to construct a concrete floor successfully. The combination of poor workmanship and good materials is problematic from a quality and performance perspective.

In addition to having five years of concrete floor construction experience, CFCA contractor

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members must have the following qualifications for membership:

- A proven commitment to quality through completed concrete floor work and client references
- An American Concrete Institute Certified Flatwork Finisher or Flatwork Technician on staff, or employed within a reasonable time of joining
- Must participate in the betterment of the concrete floor industry

CFCA contractor members must also agree to support the following Code of Ethics in the execution of their work:

Members of the Concrete Floor Contractors Association are committed to the production of high quality concrete floors by supporting the following code of business practices:

- We will make every effort to meet, and exceed when possible, the specified quality expectations of our clients.
- We will perform our work as helpful and respectful members of the project team at all times.
- We will provide our employees with a safe and healthy workplace.
- We will supply and install all specified methods and materials without unapproved substitutions.
- We will perform our work to meet the requirements of the Canadian Standard CSA A23.1 “Concrete Materials and Methods of Concrete Construction”.
- We will install all materials in accordance with the materials manufacturer’s written instructions.
- We support an environment of individual initiative and free enterprise while respecting each other’s contractual rights and privileges.
- We will participate in the future progress of the concrete floor industry through continuing research, education and the transfer of knowledge to Owners, specifiers and users of concrete floors.

Membership in the CFCA is a privilege, earned through a commitment to quality. Failure of a member to observe these guiding principles will be considered as grounds for membership suspension or termination.

Specifiers who wish to obtain superior results are encouraged to include one of the two following responsibility statements in their specification.

Divided-Source pre-qualification:

“The work of concrete floor placing, finishing, curing, jointing and sealing shall be performed by a member of the Concrete Floor Contractors Association.”

Single-Source pre-qualification:

"It is the intent of this section to establish a single competent source, being a member of the Concrete Floor Contractors Association, to be responsible to provide a complete and durable concrete floor assembly as specified herein."

The CFCA was established to provide on-going technical support to concrete floor contractors and specifiers, in an effort to reduce problems and improve quality. As such, the CFCA commits its full resources to all projects which pre-qualify CFCA members.

The use of pre-qualified CFCA members support the continuing efforts of national standards development, materials innovation, workmanship quality standards, quality control procedures and industry ethics.

It is suggested that pre-qualified trade contractors be named on the tender form. This ensures prime bidder compliance and adequate time for project planning, work scheduling and procuring specified materials.

Materials Pre-qualification

CFCA materials suppliers are major manufacturers and suppliers to the concrete floor industry nationally. Materials supplier members of the CFCA agree to the following:

- To provide information and assistance to specifiers in materials selection
- To provide site instruction and inspections when requested
- To warrant the application, use and performance of materials supplied to CFCA contractor members
- To participate in the betterment of the concrete floor industry

Most material manufacturers have both lower- and higher-quality alternatives within their product lines. The attached CFCA specification is based on the use of good quality, value-driven and performance-based solutions.

Sustainability

Our world continues to be polluted because there is no focused effort to carefully considering and managing our impact on the natural environment.

Concrete floors offer a unique opportunity in terms of sustainability, as they are a mandatory part of every building. Enhanced focus on the planning and construction of concrete floors as an exposed final finish can produce surfaces which are architectural, durable and economical.

While some facilities have a single purpose use, such as a public school, other facilities such as industrial warehouses may encounter a number of different tenants over the building's lifetime. Therefore, it is essential to consider load capacities carefully, such that future tenants and their loading requirements may also be carried by the same concrete floor. In the case of steel fibre designs, the load limits of a floor is clearly defined for future reference.

Although the deletion of reinforcement from concrete floors on ground can be perceived as "green" thinking, floors which are not fully reinforced may not perform well in the long run. Major problems such as joint curling and differential vertical joint movement are a direct result of a lack of steel reinforcing. Improving the durability of concrete floors and decreasing their future maintenance also contributes to a more sustainable world. It is generally recommended that all slab on grade floors be reinforced to sustain and enhance their long term durability and performance.

This document is distributed in an electronic format to increase its distribution and reduce paper waste.

There is no such thing as "normal" concrete any more.

Concrete Mixes for Floors

Today, it is more difficult than ever to understand and define the correct concrete mixture to produce quality concrete flooring – there is no such thing as "normal" concrete any more. There are a wide range of cements and cement-replacing materials which continue to evolve. The proportions of cements and alternative cements used varies widely from jobsite to jobsite across Canada. The correct mix must be designed for use as a concrete floor mix and be developed with consideration for the ambient conditions, including those which exist at the time of construction. The concrete mix selected must be suited for each type of slab utilization.; The drying shrinkage potential of the concrete must also be considered carefully. Enhanced concrete materials procurement and management is necessary for success.

Concrete materials are supplied to a project based on what is ordered by the "concrete purchaser", and may or may not be as specified. The traditional approach to purchasing concrete materials has been based on buying a specific compressive strength at the lowest possible price. This approach to purchasing is known to produce numerous field problems. As such, specifiers should ensure that inspectors monitor the concrete mix as it arrives at the jobsite for conformance with the project specification, CSA Canadian standards, and any approved pre-construction modifications.

Cements and alternative cements and their proportions vary considerably from job to job. Cementing proportions are occasionally adjusted at the concrete batch plant on a seasonal basis. This variability can create obstacles to obtaining consistent results. The approved concrete mix must be used without unapproved modifications.

More attention should be devoted to what constitutes the best concrete mix for each type of floor usage. The specification of interior concrete mixes has historically been based on the 28-day “compressive strength” only. Many years ago, it was possible to obtain high-quality concrete mixes this way, however this is no longer the case today. The relationship between compressive strength and concrete performance is much less meaningful today – higher compressive strengths are being achieved using lower quality concrete mixes (eg: higher water:cement ratios).

The focus on compressive strength alone has little connection to the workability, finishability, plastic shrinkage, drying shrinkage, curling, wear resistance, moisture permeability or drying time of the concrete. As such, specifiers are cautioned not to simply specify concrete based solely on compressive strength.

It is essential that the concrete mix constituents be selected carefully for each type of concrete floor usage

CSA A23.1 “Concrete Materials & Methods of Concrete Construction” mandates a standardized concrete mix for interior concrete floors with a steel trowel finish as having a maximum 0.55 water: cement (w/c) ratio. This is mandatory requirement that must be included in all concrete mix designs which are used to construct floors. This maximum 0.55 w/c ratio defines the minimum cement paste quantity required to produce a good quality trowel-finished surface. It also creates a standardized expectation of the finishability and performance of the concrete across Canada. Note that the w/c ratio does not fully define the quality of a cement paste in terms of its workability, finishability, and plastic or drying shrinkage.

From an environmental perspective, the decrease in portland cement manufacturing creates corresponding reductions in the carbon dioxide emissions of the cement industry. For more than 25 years, it has been common to use cement-replacing materials such as “slag” and “flyash” to dilute or extend the availability of portland cement. However, high levels of portland cement replacement with alternative cementing materials can produce mixtures which have different set, plastic and hardened properties. These characteristics must be carefully considered , in order to be compatible with the methods of construction and the ambient conditions.

To reduce portland cement usage, it has generally been found that up to 15% type “C” flyash or 25% slag cement may be used during the summer months. Note that type “F” flyash is not a hydraulic cement like type “C” flyash – it is recommended that it be substituted with type “C” flyash when the w/c ratio is 0.5 or less. In cold temperatures (<10°C) portland cement replacement is not recommended, due its delaying effect on concrete set and increased concern about cold weather problems, such as mix water entrapment.

A new “GUL” cement has recently been introduced to Canada, which includes up to 15% portland cement replacement with inter-ground limestone dust (called “portland limestone cement”). At this time, there is diminutive field experience with this new cement in concrete floors. Specifiers are cautioned not to permit any cement replacement with flyash or slag cements when using type “GUL” cement until the plastic and drying properties of this new blended material are better understood. GUL cement on its own is a lower carbon dioxide cementing material.

Water is the main cause of drying shrinkage in concrete. A concrete mix with a low w/c ratio (eg: ‹ 0.5) will have less free water than a concrete with a high w/c ratio (eg: › 0.6). The amount of drying shrinkage and joint curling is a function of the drying shrinkage potential of the mix. Concrete mixes for slabs on grade must be designed based on the theology of minimizing the water content to its lowest practical consistent water slump (approx. 60–80 mm). A normal-setting plasticizing admixture is then incorporated to produce a workable slump of 120–150 mm at the point of concrete placement. All admixtures should be reviewed for any increase in drying shrinkage potential. Concrete with “water only” slumps above 80 mm can produce undesirable increases in drying shrinkage with an increased risk of surface delaminations. Concrete with slumps below 100 mm are problematic from a workability perspective, leading to increased difficulties with conveying, placing, consolidating and tolerance attainment.

The use of plasticizers can also reduce cement consumption in concrete mixes with a defined w/c ratio. By reducing the water content, there is a corresponding reduction in cement content while maintaining the same w/c ratio.

Mix type:	CSA	+P
f’c:	25	25
Water:	160	145
Cement:	290	263
w/c:	0.55	0.55

Figure 4: Effect of plasticizers to reduce water & cement consumption for the same water:cement ratio concrete mix

There is little consideration for drying shrinkage, even though it is a critical aspect of slab on grade performance. In addition to water content, aggregate gradation also plays a significant role in drying shrinkage. The blending of aggregates to avoid gap grading can reduce the amount of drying shrinkage in a concrete mix. The use of fine sand, such as low

Fineness Modulus, can increase water demand and drying shrinkage as well. Excessive drying shrinkage can be a major problem for slabs on grade, particularly with unreinforced or lightly reinforced floors; because it also correlates to a greater potential for drying shrinkage curling. Concrete mixes can be evaluated and monitored for drying shrinkage conformance by using the standard test method CSA A23.2–21C.

There are a number of shrinkage-reducing admixtures available today which can reduce, and even offset, drying shrinkage completely. The use of shrinkage-reducing admixtures typically includes the need for pre-construction materials testing to determine the optimal concrete mix proportions.

CSA A23.1 defines a "low shrinkage" concrete as having a maximum of 0.04% shrinkage after 7 days of wet curing and 28 days of drying. Currently, there is insufficient data available to provide further guidance to specifiers on this issue. It is well understood that drying shrinkage causes curling – any effort to reduce drying shrinkage, such as using a plasticizer, can only benefit the floor user.

While all concrete mixes for slabs on grade should require reduced water content, the mix should also have sufficient workability to place and screed the concrete.

A normal-setting plasticizing admixture is commonly used in slab on grade construction to reduce water contents, while reconstituting the corresponding loss of slump workability. Plasticizing admixtures can take one of two forms; high-range and mid-range. High-range plasticizers are normally added to concrete on the jobsite, as they have a relatively short, time-dependent usability. Mid-range plasticizers are commonly added at the concrete batch plant, as they retard and extend usability. Mid-range plasticizers require additional care – they can occasionally cause excessive air entrapment through normal mixing action.

Concrete with plastic air contents in excess of 3% must not be combined with a machine trowel finish, otherwise delaminations can occur. The air content in concrete mixes for floors shall not be more than 3% as measured at the point of concrete placement. Note that concrete materials acceptance testing is performed at the end of the concrete chute (point of discharge), however the plastic air content may change after being conveyed to the point of final deposit. Plastic air testing should occur at the beginning of each concrete placement and continuously, until the air content is consistently below 3%. Air testing is also required by CSA A23.1 when casting compressive strength cylinders.

The use of air entrainment protects concrete from deleterious freeze/thaw cycles in the presence of water and chlorides. As interior refrigerated rink slabs and freezer floors do not cycle and are not exposed to chlorides, air entrainment is not required. Exterior rink slabs sometimes do not incorporate air-entrainment, particularly when a dense trowel finish is desired (use a maximum 0.45 w/c ratio). The combination of air-entrained concrete and a machine steel trowel finish can lead to localized surface delaminations and is therefore not recommended.

All admixtures for concrete floors must be normal-setting and low in drying shrinkage. Retarding admixtures can increase the propensity of the surface to dry before the mass of the underlying concrete has set, which can lead to plastic cracking, bumpy surfaces and surface delaminations.

Concrete mix designs are based on achieving laboratory compressive strengths after 28 days at a temperature of 23°C (ideal conditions). Lower ambient temperatures will reduce the strength gain on the jobsite than may otherwise be indicated by lab test results. Concrete strength gain slows to almost a dormant state when its temperature falls below 5°C. This is why CSA A23.1 stipulates that concrete shall be maintained at or above 10°C at the time of placing and throughout the curing period. To obtain accurate in-place strengths, "field-cured" cylinder specimens should be obtained.

Concrete materials are subject to chemical attack when exposed to acids and therefore require a suitable protective epoxy or urethane coating.

Drying Time for Applied Finishes

Most construction projects have demanding completion schedules. The drying time needed for the application of moisture-sensitive finishes can be significantly extended through the use of higher w/c ratio concrete mixes. Conventional "compressive strength" concrete mixes are a large part of this problem, as they typically have higher w/c ratios. The drying time of concrete is directly proportional to the w/c ratio of the concrete mixture; the higher the w/c ratio, the longer the drying time.

To minimize drying time, the following should be considered:

a) Decrease the total water content of the concrete mix with the use of a plasticizing admixture.
b) Decrease the water-to-cement ratio to 0.45, which has approximately half the drying time of a 0.55 w/c ratio. Similarly, the w/c ratio should be reduced to 0.45 when the concrete is poured directly on a vapour-retarding membrane, due to one sided drying.
c) Wet cure for 3 days; do not pond with water or use curing membranes.
d) Protect the slab surface from environmental re-wetting after the curing period.
e) Minimize the slab thickness consistent with structural requirements.
f) Exhaust moisture-laden air. De-humidifiers may also be used to increase the rate of evaporation.

Vapour Permeability & Vapour Retarders

The w/c ratio of the concrete determines the permeability of the concrete to water transmission, but will not eliminate moisture vapour transmission. Once fully cured, a 0.45 w/c ratio is considered to have a discontinuous pore structure with decreased moisture permeability. Water:cement ratios above 0.60 should be considered to be porous enough to allow water movement permanently. However, even a low w/c ratio concrete mix will transmit moisture vapour. To eliminate failures of non-breathing applied finishes through moisture vapour transmission, concrete floors should be placed on a vapour-retarding membrane. Vapour retarders are also effective in reducing moisture dampness in basements.

Vapour-retarding membranes should be located directly under and in contact with the concrete slab on grade for optimal performance. The installation of a vapour-retarding membrane directly under the concrete extends its drying time due to one-sided drying. Using a concrete mix with a maximum 0.45 w/c ratio helps to off-set the 200% increase in drying time caused by one-sided drying. Vapour retarders should not be installed within the granular base due to concerns over punctures and the entrapment of fluid water above the vapour retarder and below the concrete slab.

There are different qualities of vapour-retarding membranes as noted in ASTM E1745. A Class "A" vapour retarder is ideal for concrete floor use, as it has 4.5 times the puncture resistance of a Class "C" vapour retarders. Puncture resistance is vital; even a small puncture can lead to the localized failure of a non-breathing finish.

In order for vapour retarders to be effective, they must be sealed against moisture penetration by taping all joints and terminations in accordance with ASTM E1645 and the material manufacturer's instructions. Vapour retarders should extend approximately 1m past the edge of non-breathing finishes.

Polyethylene is occasionally used as a "slip sheet" to reduce under-slab friction, particularly for shrinkage-reduced concrete and post-tensioned slab designs. Slip sheets are typically perforated to permit two-sided drying and are therefore not considered vapour retarders.

Granular Bases

It is essential that granular bases be uniformly compacted to support a slab on grade from settlement and applied loading. It must also be firm enough to resist any displacement caused by concrete trucks and thus avoid undesirable variations in slab thickness.

Commonly, granular bases vary in elevation and therefore slab thickness, which can affect slab performance. CSA A23.1 states that granular bases shall be level within +/- 10mm in elevation, such that slab thickness can be maintained with some consistency. The granular base elevation must comply with this requirement prior to ordering a concrete placement.

It is not recommended that “clear stone” granular materials be used under slabs on grade due to concern over variations in elevation, increased underslab friction, the lack of compactability and long-term creep settlement.

Sloping concrete floors are commonly constructed on sloping granular bases in order to maintain the specified slab thickness. Elevation tolerance control of sloping granular bases, however, is much more difficult than when constructing a level granular base. Specifiers should consider a marginal increase in slab thickness to overcome these variations.

Inspectors should verify the elevation of granular bases as part of a pre-placement inspection.

Floor Joints

Construction, isolation and contraction joints must be carefully configured to minimize cracking due to concrete drying shrinkage, loading and vehicular impact. CFCA members commonly make recommendations for each project as part of their normal pre-construction planning.

Construction Joints

Construction joints are the weakest part of any floor. They should be located to minimize their exposure to vehicular traffic.

All construction joints in slabs on grade must be doweled for load transfer, while also permitting horizontal movement caused by drying shrinkage. Note that deformed rebar should not be used to dowel construction joints in slabs on grade as they will not be able to function correctly. Sawcut contraction joints can also be reinforced with load transfer dowels to promote load transfer and inhibit differential vertical joint movement.

Construction joints may be strengthened in vehicular environments to protect against forklift tire impact by incorporating a mortared “armoured joint” nosing of dry shake hardener (75 mm wide x 12 mm thick) or through the use of proprietary metal edge angle systems. In freezer environments, or when using shrinkage-reduced concrete or post-tensioned slab designs, metal edge angle systems have proven to be very durable.

Isolation Joints

Isolation joints are used to de-bond and prevent the influence of vertical elements and slab protrusions from affecting future concrete movement or settlement in slabs on grade. At perimeter walls, isolation joints may consist of polyethylene, waterproof building paper or 6mm flexible foam. At columns and bollards, a minimum 6mm thick foam isolation joints should be installed to allow for unrestrained vertical movement.

Contraction Joints (control or sawcut joints)

Contraction joints are commonly sawcut into slab on grade floors at predetermined locations to direct drying shrinkage in an orderly manner. When sufficient contraction joints are installed, random cracking can be eliminated in slabs on grade. Increasing the number of joints in a floor is also a notable maintenance concern in forklift environments.

Generally speaking, sawcut contraction joints should be spaced at approximately 25 times the slab thickness to no more than 4.5 metres, on centre. Advanced floor systems such as shrinkage-reduced concrete and high-steel fibre dosage rates can effectively extend this spacing to column lines (consult with materials manufacturer).

Contraction joints need to be added at points where slab thickness changes, and at any sources of restraint, to avoid cracking. Note that unreinforced and lightly reinforced slabs on grade crack more easily and often require more closely spaced joints than their more heavily reinforced counterparts.

Decorative cuts may be added in architectural concrete floors to add interest. Decorative cuts are normally installed after 28 days of drying and are approximately 6mm deep. These are not intended to function as contraction joints.

In special cases, contraction joints may be purposefully omitted in order to preserve as-built floor tolerances. For example, Superflat floors have no transverse contraction joints in order to eliminate tolerance losses caused by drying shrinkage curling. It has been found that cracks tend to stay flat and do not curl upwards like contraction or construction joints. An alternate approach in office slabs on grade areas may be to construct the floor without contraction joints, which eliminates the potential for joint curling. However, this technique also results in frequent random drying shrinkage cracks that must be restrained. While this is approach is suitable for areas covered by carpet, it is not suitable for exposed concrete or bonded applied finishes which may exhibit reflective cracking from the underlying concrete slab. A greater focus on shrinkage reduction and restraining reinforcing is required here.

Sawcutting of contractions joints is occasionally performed by someone other than the concrete floor contractor – considered a significant division of responsibility. Many sawcutting contractors do not review or anyalze the joint layout, and simply sawcut the joints as shown on the drawings, even when they may be insufficient. Such action originates from a misguided belief that following orders blindly negates any liability, should something go wrong. This mentality can be commonplace with the traditional divided-source approach to concrete floor construction. Modern concrete floor contractors actively review and recommend changes to floor joint layouts as necessary to improve quality and performance. CFCA members will submit a joint layout drawing for each project based upon their knowledge and experience, which specifiers may chose to accept or reject as they deem appropriate. The review and consideration of the floor joint layout is a critical step in pre-construction planning.

Reinforcing for Slabs on Grade

Professional engineers must carefully analyze and consider the individual requirements of each floor in order to derive the best design solution. In addition to designing for specific loading conditions, designers must also carefully consider the effects of drying shrinkage curling as well.

There are a number of design approaches available for concrete slabs on grade, ranging from plain concrete with doweled joints to heavily reinforced concrete. CFCA members often make design recommendations based on their past experience in the industry.

Concrete slab on grade design begins with defining any applicable loading conditions. The choice of a final design requires consideration of several aspects; 1) the granular base support, 2) the quantity of reinforcing, and 3) the compressive strength of the concrete mix. Through purposeful manipulation of these variables, a variety of slab thicknesses can be created for any given load condition. By combining the labour and materials costs for reinforcing and materials, an optimal cost curve can be developed. The designer can choose from a range of thicker unreinforced floors or thinner reinforced floors to suit their needs.

While the primary focus of slab design is the applied loading conditions, the restraint of drying shrinkage curling is essential for every slab on grade floor. All concrete shrinks as it dries – and slabs on grade also dry differentially, such that the slab surface dries more thoroughly than the bottom. This drying differential causes an upward curvature or “curling” at all floor joints. As previously noted, curling is correlated to the shrinkage potential of the concrete materials. Curling can be extremely problematic for the aesthetics of both exposed concrete and concrete under an applied finish.

All slab on grade designs must include consideration for reduced drying shrinkage curling through concrete mix water reductions, the inclusion of water-reducing plasticizing admixtures and the addition of sufficient restraining reinforcing steel.

Unreinforced Plain Concrete Floors

Unreinforced or plain concrete design solutions are generally the thickest floors which promote the use of concrete materials over slab reinforcing. This can have cost advantages, if concrete materials are inexpensive. While this is perceived to be suitable for foot traffic environments, it is generally not recommended because the long term performance and future maintenance of this design can be problematic.

In particular, the choice of an unreinforced floor design requires careful consideration in terms of concrete drying shrinkage potential, load transfer at joints, and joint location and spacing.

The theory that concrete “aggregate interlock” will allow load transfer and hold the joints from moving differentially is not widely supported. It has been found that the normal drying shrinkage of conventional concrete exceeds the limits of aggregate interlock design theory, which is based upon a maximum 0.035” of joint opening (whereas 0.60” is common). Repetitive loading from forklift or other vehicular traffic can degenerate aggregate interlock further.

Floor joints in fully unreinforced floors are able to move freely because they are unrestrained; there is no mechanical connection. Drying shrinkage curling at joint intersections has been observed at upwards of 25mm in unreinforced and lightly reinforced concrete floors. To promote joint stability, load transfer and durability, all sawcut contraction joints in unreinforced slabs on grade should be reinforced with a suitable load transfer assembly at a minimum. While the addition of load transfer dowels at contraction joints does eliminate differential joint movement, it does not eliminate drying shrinkage curling.

Specifiers need to consider that as-built concrete floor tolerances may be reduced by as much as 25–50% due to drying shrinkage curling in plain unreinforced concrete. This can have a profound effect on the usefulness of a floor surface, as well as its final appearance. After defining a suitable floor tolerance, specifiers must carefully select the concrete materials and restraining reinforcing to reduce or eliminate drying shrinkage curling to suit their needs.

Fully unreinforced floors are generally not recommended as they crack easily, use more cement and concrete, exhibit the maximum amount of unrestrained curling, require closer joint spacings, have low load transfer across joints, and have a higher future maintenance potential in vehicular environments.

“Micro” Synthetic Fibres

Micro synthetic fibres are a very fine, hair-like material which enhance the plastic properties of unhardened concrete. Micro synthetic fibres do not provide any meaningful drying shrinkage control, curling restraint or add any load capacity to hardened concrete. Micro synthetic fibres have dosage rates varying from 0.5 to 1 kg/m^2.

Welded Wire Mesh

Welded wire mesh has been used for decades to obtain a low-cost, mechanical connection across contraction joints. Welded wire mesh comes in a variety of wire gauges and spacings. Wire mesh with a closer spacing and thicker gauge can provide increased restraint (4x4 4/4 or lower). While wire mesh is the lowest cost “steel” option, it has limited capacity to restrain drying shrinkage curling at normal spacing and gauges (6x6 6/6 or less).

Wire mesh is rendered useless if it is lying on the granular base. Due to its flexible nature, the elevation of wire mesh will vary – there should be no expectation of wire mesh to be consistent in elevation within a concrete floor. A higher gauge wire at a closer spacing can reduce this flexibility and improve elevation control.

While the use of chair supports can help to raise the mesh locally, they are often unstable. Chairing also creates accessibility problems and may require more expensive concrete placing and screeding operations.

While many designers call for wire mesh to be located in the top 40 mm of a slab, this is problematic as the mesh will be sawcut when installing contraction joints. If the mesh is cut, its ability to stabilize contraction joints will be lost.

In some industry publications, it is recommended that wire mesh be discontinuous across contraction joints in slabs on grade. It has been shown through experience that continuing the wire mesh through contraction joints does not have any effect on cracking potential of the concrete – wire mesh does not stop drying shrinkage cracking but it can promote joint stability.

It is not practical, nor recommended, to specify two layers of wire mesh as a design solution as this is extremely unpractical.

It is highly recommended that all exterior “architectural” pavements be reinforced with one layer of welded wire mesh to avoid differential joint movement caused by frost-heave.

Rebar Reinforcing

Rebar reinforcing can be installed in a single layer as temperature reinforcing, or in two layers in heavily loaded environments. Temperature reinforcing holds the concrete together but does not increase its load capacity. Unlike wire mesh, a single layer of rebar can be maintained at a specific elevation and is effective in restraining drying shrinkage curling forces. Rebar may also bind some contraction joints together, resulting in drying shrinkage cracking.

Due to its higher cost, two-layer rebar solutions are generally reserved for the heaviest loading conditions or with poor soils support.It is unnecessary to install contraction joints in two-layer rebar slab designs, as these joints do not function normally when restrained in this manner.

Rebar reinforcing is subject to corrosion deterioration from road salts. Rebar used in exterior applications must be protected from corrosion by using the correct concrete materials, maintaining sufficient concrete cover, providing adequate slopes, and other protective measures such as membrane protection systems (See CSA S413 for Parking Garages).

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Steel Fibre Reinforcing

Steel fibre reinforcing has become the leading design solution for most industrial floors due to its practicality and remarkable performance. Steel fibres can turn brittle concrete into a more ductile material. Dosage rates for steel fibres vary from 15 to 45 kgs/m^3 – the higher the dosage rate, the greater the performance. Dosage rates of 20kgs/m^3 or higher are generally required to improve the load capacity of the concrete (consult with fibre manufacturer).

Each fibre type is unique in its performance. As such, design loading conditions must be unique for each fibre type. Fibre alternatives and substitutions must not be made without a design review.

Steel fibre performance increases proportionately with its length/diameter "aspect" ratio. Generally speaking, the higher the aspect ratio, the greater the fibre's performance in hardened concrete. The method of anchorage and the tensile strength of the wire also play a critical role in its performance. Figure 5 shows seven different fibre types with their corresponding load carrying capacities at equal dosage rates. Each manufacturer must provide a separate design for their particular fibre type.

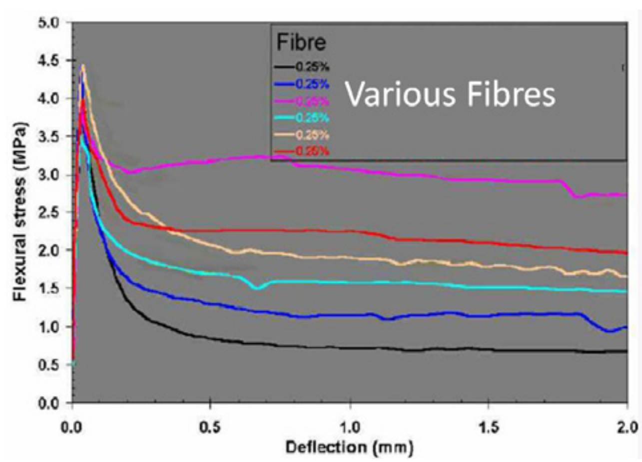

Figure 5: Load carrying capacities of various fibre types

Steel fibres can increase the load capacity of a slab on grade, but must be designed for each particular loading condition. As noted, each fibre type/configuration has a different cost and performance characteristic, which are not equal at the same dosage rate. Purchasing based solely on price per kilogram is misleading as higher performance fibres have a higher price but also have higher load capacities.

Steel fibres shall comply with ASTM A820 type 1 and have the following minimum qualities:

- Tensile strength of the wire: › 1100 MPa
- Ultimate Strain: ‹ 4%
- Length: › 40 mm
- Aspect Ratio: minimum 44
- Minimum Residual Strength Factor R(e,3) of 30%

CFCA steel fibre manufacturers will supply their design calculations on each project, detailing the load capacity of their fibre design. Projects which specify “steel fibres at 25 kgs/m^3” overlook the fact that each fibre type has a different performance capacity. CFCA steel fibre manufacturers can reverse-calculate their load capacities from a dosage rate specification to interpret the end load capacity of a slab. This is extremely helpful when comparing different fibres in terms of performance and value.

The following considerations must be indicated in steel fibre design calculations:

1. K value of granular base support
2. Concrete compressive strength
3. For ultimate limit state, the governing load case
4. For serviceability limit state, the governing load
5. Coefficient of friction between slab and sub base
6. Floor thickness
7. Fibre Dosage rate
8. Fiber type
9. Maximum joint spacing
10. Joint load transfer.

While fibre reinforcing is largely concealed within the concrete, some fibres may be visible at the slab surface or at contraction joints. Note that the application of a 3 kg/m^3 dry shake surface hardener can aid in covering surface fibres from view. Concrete polishing and preparation methods for applied materials may also expose embedded fibres. – CFCA contractors are able to calculate the best value for a given loading condition, utilizing variables of concrete cost and strength, slab thickness, and fiber cost and dosage rates. Contrary to a simple cost comparison, the least costly floor assembly often utilizes high performance/cost materials for any given loading condition.

Steel fibres at dosage rates of 20 kgs/m^3 or higher can reduce the effect of drying shrinkage curling to minimal levels (consult fibre manufacturer).

Unlike wire mesh and rebar reinforcing, steel fibres have been proven to have no affect on in-floor wire guidance systems.

Steel fibres will exhibit localized spot rusting when exposed to acids or chlorides; which is cosmetic in nature. It is not recommended to acid etch steel fibres floors as a preparation method.

Steel fibres are an effective solution for exterior concrete pavements. Due to their relatively small diameter and their discontinuity, they do not produce corrosion-induced delaminations like reinforcing steel bars.

The use of higher dosage rates of steel fibres can produce extended joint spacings. Please contact your CFCA steel fibre manufacturer for further information regarding the design of these special surfaces.

“Macro” Synthetic Fibres

In recent years, synthetic “macro” fibres have been developed as shrinkage and temperature reinforcing with the capacity to enhance the toughness of concrete. Marco synthetic fibres are approximately 50 mm long and have dosage rates varying from 1.8 to 5 kgs/m^3. Synthetic fibre materials do not have surface corrosion potential like steel fibres do.The creep-strain performance of some synthetic macro fibres may decrease over time (refer to fibre manufacturer).

Just as there are no fixed substitution rates between different types of steel fibres, there is no equivalent relationship between different macro synthetic fibres. There are also no fixed substitution rates between steel fibres and macro synthetic fibres. The substitution of one fibre product for another fibre product is never equal – each fibre must be designed based on its own performance.

In addition to providing design load calculations, CFCA fibre manufacturers can also provide joint load transfer calculations.

Concrete Floor Tolerances

There are two major tolerances applicable to concrete floors; slab thickness and surface profile.

Thickness Tolerances

Slab thickness must be maintained within reasonable limits so as not to affect the load capacity and performance of a concrete floor. The parameters of slab thickness need to be controlled in order to meet the desired performance expectations. Slab on grade thickness can be affected by variations in the granular base and finished floor elevations, which vary independently of each other. In accordance with CSA A23.1, the average thickness of a slab on grade concrete floor shall not be more than 10mm less than the specified thickness, with no local area being more than 20mm less than the specified thickness. This means that a 100mm thick floor must be “on average” no less than 90mm thick, and no less than 80 mm thick in any local area.

CSA A23.1 permits the use of a non-destructive impact echo device to verify slab thickness. The impact echo device must be calibrated against a core to verify its accuracy. CSA A23.1 states that slab thickness tolerances “should” be taken within 7 days of each slab placement. When this type of testing is employed, it is desirable to perform this early, such that if any necessary corrective action is required, it can be performed with the least possible impact on the project schedule or to the owner.

Suspended formed slabs and slabs on metal deck are screeded using a depth gauge to maintain the specified slab thickness to within ffl20 mm. Supporting formwork and metal decks are typically cambered, which settle and deflect upon loading. Attempting to screed concrete floors to a specific elevation using a laser on a suspended slab is neither practical nor effective – slab thickness may be compromised or be affected by further deflection. For enhanced elevation control on suspended slabs, a deferred bonded topping should be used.

Surface Tolerances

The surface profile of all concrete floors consists of a series of hills and valleys, varying in magnitude and wave length. These variations can be controlled by selecting an appropriate screeding and finishing technique. Materials modifications may also be required. Increasing the requirements for flatness and levelness in specifications tends to result in higher costs, depending upon the complexity of the workmanship methodology. Specifiers should carefully select from CSA A23.1 a tolerance based on the owner’s needs and the floor’s surface usage.

Traditional “straightedge” type flatness tolerances have been proven ineffective in practical terms to both define or produce flatter concrete surfaces Straightedge tolerances are therefore not recommended for concrete floors.

Concrete floor surface tolerances must be based upon the F-number system which individually defines the flatness (FF) and levelness (FL) of a concrete floor surface. Floor levelness “FL” is based on changes in elevation 3 metres apart relative to a level plane. Floor flatness “FF” describes the bumpiness of the surface based on a 600mm curvature from changes in elevation 300 mm apart. FL tolerances are applicable to slabs on grade and bonded deferred toppings, but are not applicable to sloping floors or suspended slabs. FF tolerances can be applied to all types of concrete floor surfaces.

Elevated suspended slabs exhibit variations in elevation caused by camber, settlement and deflection. ACI 435 “Control of Deflection in Concrete Structures” states that the magnitude of actual deflection in concrete structural elements “can only be estimated within a range of 20–40% accuracy”. These elevation deflections are beyond the ability of a concrete floor finisher’s control. As a result, FL tolerances are not applicable to elevated slabs. Enhanced levelness in suspended slabs can only be created through the use of deferred bonded toppings.

There is no mandatory requirement to measure floor tolerances – the choice to do so lies solely with the owner and specifier. The costs of third party tolerance testing are the responsibility of the owner.

When surface tolerances are employed as acceptance and rejection criteria, they must be measured within 72 hours of each slab placement. Measurement of surface tolerances after this time can be influenced by drying shrinkage curling, which can significantly reduce the as-built quality. A delay in tolerance measurement unnecessarily permits compounding of defective results and the need for greater corrective action. Concrete floor contractors commonly use tolerance information to confirm or modify method and materials to achieve the specified results. Concrete floor flatness and levelness tolerances are produced by selecting compatible methods of construction. Specifiers need not be concerned with specifying methodology, beyond the need to define the necessary floor flatness and levelness tolerances required for any particular surface.

Tolerances for common surfaces are specified in CSA A23.1. Specifiers may also define customized tolerances for special surfaces in consultation with materials handling system manufacturers. Existing concrete surfaces may be measured to guide the selection of a suitable tolerance for a new surface. Specifiers are cautioned that the use of customized tolerances may require other design changes to materials and methodology.

All concrete floor surface tolerances must be included within the concrete floor specification section. Some applied finish manufacturers define surface tolerances based upon the straightedge method, which is not compatible with the F-number system. The CSA A23.1 Class “B” tolerance is the highest class available to institutional floors. The methodology associated with this class of floor produces a range of tolerance results from FF25–35 (specified as FF25). Note that “pan floating” methodology is required to produce these tolerances.

Concrete floor contractors attempt to exceed specified tolerances as a best practice. Lower tolerance results may occur with inadequate concrete materials or in hostile ambient conditions.

The F-number system also includes a minimum local value that defines the lower boundary of acceptability. Measured tolerance values cannot be less than 60% of the specified

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tolerance value for any localized area. Failure to exceed this minimum local value requires significant corrective action.

Table 21
Slab and floor finish classifications
(See Clauses 7.6.1.1, 7.6.1.4, and 9.2, and Figure D.2.)

			Overall *F*-number	
Class	**Examples**	**Recommended procedures**	F_F	F_L
A	"Conventional" slab on grade and elevated floors	Hand screeded and steel trowel finished	20	15*
B	"Flat" slab on grade and elevated floors or surfaces with thin applied finishes.	Advanced hand or mechanical screeding, pan floating, and steel trowel finished	25	20**
C	"Very Flat" slab on grade floors	Specialized materials, advanced hand or mechanical screeding, pan floating, and steel trowel finished	35	25
D	"Extremely Flat" slab on grade floors	Specialized: materials, advanced mechanical screeding, large pan float, highway straightedged, and steel trowel finished	45	30
E	Specialized surfaces including automatic guided vehicles and air pallet systems	Specialized materials and methods of concrete construction	†	†

**Class A and B Levelness tolerances are not applicable to elevated slabs.*
†Refer to equipment manufacturers instructions.

Notes:

(1) *Many items can affect the achievement of specified tolerances, including placement methods, concrete consistency, concrete thickness, the application of surface hardeners, environmental conditions, and physical restrictions of the placement area. These should be reviewed carefully at the concrete floor pre-construction meeting.*

(2) *It is not possible to obtain Class B tolerances on elevated slabs where double pan float machines cannot be employed for reasons of safety or accessibility.*

(3) *Tolerance losses of up to 50% can occur in a jointed slab on grade through drying shrinkage curling in the first year. Owners are cautioned to consider these losses carefully when designing floor slabs including the use of shrinkage reducing admixtures and restraining reinforcing steel to meet their needs. See ACI 360 for further information.*

(4) *Owners may specify tolerances other than those listed in this Table after carefully considering their actual usage requirements. Owners are cautioned that higher tolerance specifications generally require more expensive methods of construction including modifications to concrete mixes, reinforcing, and surface treatments.*

(5) *Specialized Class E floors involve customized floor tolerances, materials, and methods of construction that are beyond the scope of this Standard. Specialists should be consulted for this type of traffic surface. Further information is available from the Concrete Floor Contractors Association of Canada.*

(6) *Improved levelness tolerances on suspended slabs* generally *require the use of a deferred bonded topping. Tolerance Class A through E may be applied to bonded toppings.*

(7) *Compliance with the ASTM F710 requirement for F_F30 is generally achievable using the methodology in Class B.*

(8) *"Small slab on grade floor areas less than 150 m² may alternatively comply with a 90% compliance to a 12 mm "conventional" gap under a freestanding 3 m straightedge in accordance with ACI 117.*

(9) *Measurements shall be taken within 72 h of each slab placement.*

Figure 6: Table 21 excerpt from CSA A23.1-2014

The topside elevation of concrete slabs on grade must be within ffl20mm in elevation. Using advanced screeding methods, such as a Somero laser guided screed machine, this elevation variation may be less than ffl10mm. Rink slab construction often demands better control of elevations (ffl6mm), but these are extremely difficult to achieve and caution must be exercised. Rink slabs should be constructed using single-source responsibilities due to their complexity.

Where the free drainage of water is required, without any physical assistance, a 2% nominal slope should be specified. Slope percentages of less than 1.5% typically include the expectation that normal surface variations will likely produce bird baths along the drainage line. The use of non-slip finishes on sloping floor surfaces may also reduce the free drainage of water. Using strip pour methodology, the slope percentage and variations may be reduced for special surfaces, such as food production facilities and aircraft hangers. A 2% slope is too large for exterior patio surfaces where tables, chairs and patrons will be affected.

FF and FL tolerances are for random traffic surfaces only. In special environments where automatic guided vehicles are used in a fixed wheel path environment, a separate “Fmin” tolerance system is used. Please contact the CFCA office for further information on these special surfaces.

All tolerances must be carefully outlined at the pre-construction meeting to be clearly understood.

Surface Finishes

While most interior surfaces require a smooth steel trowel finish, there are a variety of standard surface textures available for selection by the specifier for regular and architectural purposes.

Standard hand and machine finishes include:

Non-slip Finishes:

- Broom finish
- Hand float swirl finish
- Machine float swirl finish
- Flat trowel with light broom

Smooth Finishes:

- Flat trowel – smooth and flat appearance without a shine
- Burnished trowel – smooth and shiny appearance

Surface textures may also be specified to add different effects and include:

- Stained & dyed concrete

- Pigmented concrete
- Imprinted or stamped concrete
- Exposed aggregate concrete
- Polished concrete

See Part 3 of this document for **reference photographs**.

Mock-Up Samples

Specifications must clearly define the owner's expectations. This can be difficult – a mock-up sample can serve to define these expectations clearly. In the case of architectural concrete floor finishes, mock-up samples are necessary to meet expectations. Mock-up samples are expensive and must be specified, otherwise additional costs will be incurred. Mock-up samples are not necessary for standard float and trowel finishes unless unique concrete materials or applications are being considered/tested.

Mock-up sample costs may be minimized by creating these samples on-site, where they may be covered by subsequent applied finishes. Specifiers may also participate at an initial concrete placement to help finalize finishes. Mock-up samples must be large enough to utilize the same methods and materials that will be used in full-scale construction. Specifiers are cautioned that small hand-out, sample sizes do not usually reveal normal variations in appearance for any particular finish.

Specifiers may refer to other completed projects by the same concrete contractor for reference, avoiding the need for mock-up samples. CFCA members are pleased to assist specifiers in this manner.

Wear Resistance & Colouration

The weakest part of a floor slab is its surface. While a concrete mix may be hard in compression, its surface may not be durable in terms of wear resistance. While higher strength concrete mixes generally have higher wear resistance, they also have higher cement contents and the potential for greater drying shrinkage.

Most concrete floor environments are covered through the use of the standard CSA A23.1 concrete mix, having a maximum w/c ratio of 0.55 as well as a suitable curing regime.

For interior surfaces subject to vehicular traffic, the application of hard aggregates to the slab surface is recommended to increase wear resistance.

Wear & Abrasion Resistance

In vehicular environments, wear resistance is increased with the application of hard aggregates to the concrete surface while it is in a plastic state. These aggregates can be applied at one of three application rates: light (3kg/m^2), medium (5 kgs/m^2), or heavy (7 kgs/m^2). These rates are selected based on the volume of traffic; medium or heavy in loading dock areas and light in storage areas. Depending on the compatibility of the concrete materials and the ambient conditions, a 10–15% variation in application rates should be considered normal.

The application methodology for surface hardeners varies depending upon the application rate. Surface hardeners can be applied in two ways – hand application and/or mechanical application. Hand application is acceptable for light to medium application rates, whereas mechanical application is best for medium and heavy application rates. Occasionally, mechanical application is used for the first coat and hand application is used thereafter.

There are a number of different types of aggregates to choose from as a dry shake hardener, including traprock, silica, emery (heavy duty), ferro-silicon or metallic. Illustrated in Figure 7, each aggregate type produces a successively greater abrasion resistance. Concrete topping mixes may also be manufactured with harder coarse aggregates such as traprock, emery or metallic as well. Traprock aggregate toppings have been used for decades to produce very hard-wearing industrial floor surfaces. In waste transfer facilities, emery and metallic aggregate toppings are commonly employed to resist very high surface abrasion.

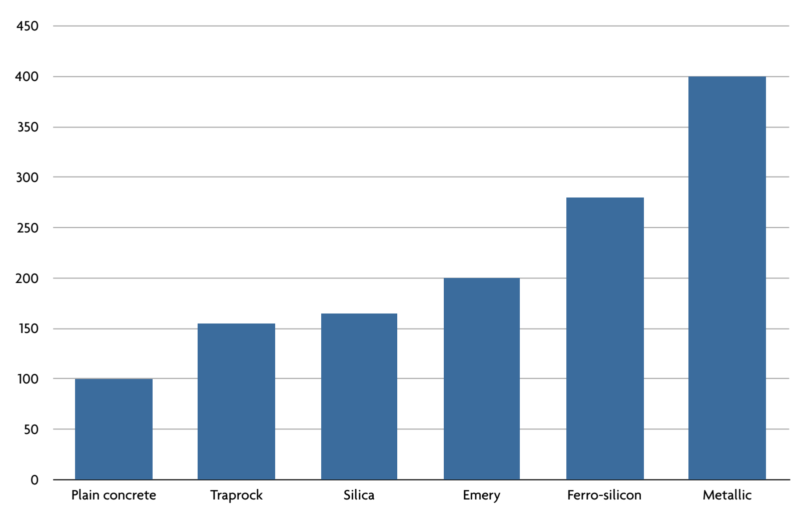

Figure 7: Abrasion improvement using different aggregates

Concrete surfaces may be coloured by acid stain, dye, integral colouring, or surface colouring. Colour charts are available from manufacturers.

Pigmented dry shake hardeners are the most economical and durable solution for interior surfaces, as they combine colour and improved wear resistance. While most colour selections are comparable in cost, some colours carry significant cost premiums, such as blue and green. Pigmented colours must be specified at a 7 kg/m^2 application rate to ensure colour uniformity.

Light reflective floors offer an opportunity for energy savings by reflecting overhead light energy. By re-using light, an increase in the spacing of light fixtures can result in energy savings. Light reflective floors were originally developed for use in aircraft hangers where aircraft wings cast shadows in underlying work areas. Based on this premise, they have been used in commercial and industrial environments to enhance light levels. In addition to reflecting light, these surfaces also have improved wear resistance.

The edges of construction joints may also be densified by installing a mortar nosing or “armoured joints”. It is unnecessary to provide “armour joints” in areas which are not subject to vehicular traffic, such as under racks.

Integral concrete hardeners are available to enhance the wear resistance of concrete. They are particularly useful in exterior applications, where the air-entrainment system could be affected by applying a surface hardener. As with integral colours, the cost of mixing a hardener throughout the entire concrete mass has debatable value – realistically, only the surface requires enhanced abrasion resistance. Improvement in wear resistance is positively correlated to the hardness and percentage of aggregate replacement.

Acid Stains & Dyes

Acid staining and dying involve liquid colour application after 28 days of air drying. Stains are semi-transparent in appearance, whereas dyes are more uniform in colour. These penetrating materials are less maintenance-intensive than surface coatings because they penetrate into the concrete and do not lie on its surface.

Stains and dyes may be installed as a single overall colour or in patterns. Specifiers wishing to use more than one colour should illustrate the pattern and colours on the architectural drawings.

Stains and dyes may also be combined with stencils to produce a variety of floor art, ranging from borders and medallions to corporate slogans and logos. These must also be detailed clearly on the project drawings.

Integral Colouring

Integral colouring is the process of mixing pigments throughout the concrete, such that the entire slab thickness is coloured. This is ideal for exterior environments to preserve the

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freeze thaw durability of the concrete. While it is more expensive to pigment the entire slab thickness as compared to surface colouring, integral colouring can add further interest to the appearance of some specialty finishes, such as deep ground polished concrete and exposed aggregate. The cost of integral colouring can be reduced by applying the concrete as a monolithic or deferred topping rather than pigmenting the entire slab thickness.

Unlike surface applied colours, there is no enhanced wear resistance obtained through integral colouring.

Specifiers must select a colour and dosage rate for integral colouring in consultation with the pigment manufacturer.

Note that both surface and integral colours must be installed in separate concrete placements.

Curing

In accordance with CSA A23.1, all concrete floor surfaces must be cured through:

"the maintenance of a satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that desired properties can develop."

Concrete floor surfaces which are not cured are weaker and dusty compared to those which are properly cured. Uncured concrete can lead to premature surface wear.

Water curing provides additional moisture to the concrete surface, maximizing hardness and wear resistance for any given concrete material. Surfaces scheduled to receive penetrating sealers, bonded applied finishes and cement mortar beds must be wet cured. A minimum 3-day curing period is required for all surfaces. Enhanced surface hardness is obtained by extending the curing period to seven days – recommended for all exposed concrete floor finishes.

Curing membranes offer an alternative to wet curing – they do not supply additional water for cement hydration, but form a film which retains moisture when applied in accordance with the manufacturer's instructions. Curing membranes significantly reduce the rate of moisture lost from the concrete and should not be used where moisture-sensitive finishes are scheduled to be applied (use 3-day wet cure here).

Curing membranes are relatively soft and thus not designed to be durable or long-lasting under foot or vehicular traffic. Curing membranes are available in either clear or pigmented forms. Pigmented curing membranes are designed to be compatible with underlying pigmented surface hardeners and are not meant to be used as a finish on their own.

Curing membranes are commonly used on exterior concrete surfaces and may be clear or white pigmented. White pigmented curing membranes are designed to reduce heat absorption of concrete during the curing period.

Curing does not affect the amount of drying shrinkage curling – even well cured floors will curl. Specifiers must reduce concrete shrinkage and add sufficient reinforcing steel to restrain tolerance losses due to drying shrinkage curling (see “Reinforcing” above).

Joint Fillers

Joint fillers fall into two categories. Sealants, which are flexible elastic materials that are meant to seal a joint from dirt and debris, and load bearing fillers, which are semi-rigid and designed to protect joint edges from deterioration caused by forklift traffic wheel impact. The use of flexible fillers in forklift traffic environments can lead to premature joint deterioration.

Joints subjected to vehicular traffic must be filled to protect the joint edges from impact deterioration. Load bearing fillers are filled to the full depth of the contraction joint. Full-depth fillers should not be installed on a back rod, as this may cause the filler to displace vertically.

Joints subject to foot traffic, or located under racks or equipment, may be left unfilled or filled 12mm deep with an elastic sealant on a backer rod. Joint sealing is optional for these environments, but may be desirable for aesthetic purposes or to prevent intrusion of dirt or debris. All floor joints in food processing and storage facilities are required to be sealed.

Premature joint filling is a major concern. If joints are filled too early, the filler materials will de-bond from the joint face due to the drying shrinkage of the concrete. This is not a defect in materials or workmanship, it is simply a result of the drying shrinkage of the concrete exceeding the bond capacity of the filler materials. All filler materials are designed to de-bond rather than bond the concrete joint faces together (which would cause cracking). Flexible sealants should only be installed after 75 days of air drying; semi-rigid fillers installed after 120 days of air-drying (at 20°C).

It is not recommended to temporarily fill joints at 28 days and then repair them at a later date. This has proven to be extremely costly and problematic.

Joint sealants and fillers are commonly grey or amber in colour but they may also be pigmented (refer to manufacturers colour chart).

No joint filler material will protect joint edges from steel wheels and steel-tracked vehicles. Protective mats should be used to protect the concrete surface from steel-tracked vehicles. Extended joint spacing and joint-free designs are recommended for these environments.

Please contact the CFCA office for additional assistance as these may require a customized approach.

Sealers, Coatings & Densifiers

Floor Sealers & Coatings

There are two classes of floor sealers; surface sealers and penetrating sealers. As their names imply, surface sealers sit on top of the concrete while penetrating sealers penetrate through the surface into the concrete.

Surface sealers are advantageous to protect the underlying concrete from staining, chemical attack or provide a pigmented appearance. The main disadvantage of floor sealers is that they can be worn and scratched off the surface by traffic and require re-coating over time. Surface sealers which are too thin will wear away quickly under vehicular traffic and require more frequent re-coating.

Surface sealers provide a number of benefits:

1. Easy cleaning
2. Stain protection
3. Clear or pigmented alternatives
4. Acid resistance (urethane and epoxy)
5. Enhanced surface wear resistance (urethane and epoxy)

Acrylic sealers, urethane coatings, and epoxy coatings are the three types of floor sealers.

Acrylic sealers are inexpensive and have low wear resistance compared with urethane and epoxy coatings. They are commonly used as curing membranes and to seal interior surfaces inexpensively. Specifiers are cautioned that these acrylic sealers require more intensive maintenance than the more durable urethane and epoxy finishes.

Urethane and epoxy coatings come in a variety of chemical formulations to protect concrete from chemical attack. These sealers may also be applied in a variety of smooth or non-slip textures, depending on the floor usage. The life expectancy of a urethane and epoxy floor sealer is proportional to their thickness. It may be best to increase coating thickness to reduce the frequency of re-coating. These factors should be reviewed carefully with the materials manufacturer prior to their specification.

Epoxy materials may be clear or pigmented and are both wear-resistant and can be customized for a variety of chemical exposures. Concrete surfaces must be protected against the deleterious effects of acid attack. Epoxy materials are also commonly used for decorative floor systems, including quartz and terrazzo. However, epoxy must not be used in high-temperature environments (›50°C).

Urethane coatings are wear-resistant, chemical-resistant and high-temperature resistant. Urethane materials can be clear or pigmented. Note that less expensive urethane materials may not be UV light resistant and may amber in colour. Urethane floor systems are commonly used in areas where very hot water or steam cleaning are used (>50°C).

Urethane and epoxy finishes require the surface of the concrete to be mechanically abraded to enhance their chemical bond to the concrete. This may reveal fibres in the concrete which were not visible prior to surface preparation. Fibres which extend above the concrete surface should be removed prior to sealing. Acid etching as a means of preparation is discouraged and should not be used on floors containing steel fibres.

Penetrating Densifiers

Penetrating liquid silicate densifiers have proven to be an economical and effective treatment for exposed floors. Liquid penetrating sealers/densifiers are water based materials that penetrate the concrete and react chemically with the hydrated cement to densify the surface. This reaction takes place over many months and is not immediately obvious, such as a surface sealer application. These materials are very inexpensive and cannot be scratched off as a surface coating may be.

Penetrating densifiers are not classified as curing membranes since they do not retain the moisture needed by cement to harden. Penetrating densifiers are also not acid-resistant.

Exposed warehouse and commercial retail concrete floors are commonly treated with these silicate materials due to their low cost and low maintenance. With power scrubbing, these floors can take on a semi-gloss sheen over time.

In addition to penetrating densifiers, there are also penetrating silane sealers which repel water penetration into the concrete.

The choice of surface treatments should be made in consultation with our materials manufacturers. All materials must be installed in accordance with the manufacturers written application instructions.

Special Concrete Floor Surfaces

While each floor is unique in terms of on-site construction, some floor surfaces have special design and construction considerations related to their complexity of construction or final appearance.

It is strongly recommended that all specialty surfaces be specified using a “single-source“ full responsibility approach to eliminate confusion which can interfere with the final appearance or performance of these specialty surfaces.

If you are designing a floor which is unique, please contact the CFCA office for further assistance.

Exposed Concrete as an Architectural Finish

Anytime that concrete is designed as a final exposed finish, it should be considered as "architectural" in nature. Architectural surfaces require enhanced coordination of materials and methods using the "single-source" approach to responsibilities.

Ice Rink Slabs

Rink slabs are one of the most challenging concrete floor installations. They are constructed in a single day, in a succeed-or-fail environment that requires special planning and care.

In particular, rink slabs require extremely careful coordination of elevations from the underlying sand bed, insulation, refrigeration system piping support and through to the final concrete surface. It is recommended that the concrete floor contractor install the slab insulation to ensure that surface elevations are not affected by underlying elevation problems in the supporting sand bed.

Large variations in concrete quality or a failure of the concrete pump can create major cold joint problems. A stand-by or back-up concrete pump should be specified for all rink slab installations.

Specifiers should consult with the refrigeration system manufacturer for further recommendations on ice rinks and freezer floor construction.

Bonded Concrete Toppings

Bonded concrete toppings are used for a variety of reasons:

- To minimize the costs of casting expensive materials at a full slab thickness
- To defer the application of final architectural concrete finishes
- To make a flat & level floor on a deflected suspended slab
- To reinstate an old floor

Toppings are commonly deferred until a suitable time and then cast onto a hardened base slab as a "deferred" bonded topping. Specialty toppings may be cast monolithically, while the base concrete is still in a plastic state.

The recommendations of the bonding agent manufacturer should be followed at all times.

The basic steps to successful bonded topping construction are:

1. Suitable base slab preparation
2. Selection and application of a suitable bonding agent material
3. Selection, placement and finishing of lower shrinkage concrete topping materials
4. Wet curing for seven days with an additional 7-day protection period

Each of these elements is critical. A failure in preparation, bonding, concrete materials or curing can lead to topping bond failure.

For industrial toppings, we recommend the use of traprock coarse aggregate and the addition of 25 kgs/m^3 of steel fibre reinforcing, to add wear resistance and toughness to the concrete topping.

Reflective cracking is a common concern for all bonded toppings, where existing base slab joints or cracks can reflect through to the surface of the bonded topping. Careful coordination of base joints and topping joints is required to minimize this concern where possible. Base slab cracks may be pre-treated to minimize this problem (consult with bonding agent manufacturer).

Superflat Floors

Superflat floor construction is necessary with automatic guided vehicles in fixed wheelpath and wire-guided vehicle environments.

A special "Fmin" tolerance system is utilized, which is different from the FF/FL random traffic tolerance system. This Fmin tolerance system is based on the actual footprint of the vehicles to be used.

These floors are poured in long narrow strips that mimic the rack aisle layout. To eliminate the effect of drying shrinkage curling, there are no transverse contraction joints in Superflat floors. Longitudinal reinforcing is required to minimize the width of expected transverse cracks along the length of the strips.

The CFCA is pleased to assist you with further information on all types of concrete floor surfaces.

CFCA Concrete Floor Warranties

CFCA members will supply a basic "Cement Finishing" one-year warranty, assuring the specifier that the work has been constructed as specified and within the limitations of the divided-source scope of work as performed.

CFCA members will supply an extended "Concrete Floor" two-year warranty for concrete floors specified and constructed using the single-source full responsibility approach to construction. Single source warranties include the repair of drying shrinkage cracks.

A desire for longer warranty periods and superior floor performance generally requires the design participation, the single-source full responsibility approach, and planned maintenance by the concrete floor contractor.

CFCA firms warrant that within the limitations of their contracted scope of work, all projects shall be completed in accordance with the project plans, specifications and the requirements of CSA A23.1.

CFCA firms will provide a written warranty against defects in workmanship and supplied materials on the standard association warranty form.

Warranty work is generally based on re-working the concrete materials and not their replacement. Slab replacement warranty provisions must be based clearly specified and must be based upon the specification of a single-source full responsibility approach to construction.

Warranty type 1: Basic (Divided-Source Approach):

- One (1) year against defects in supplied workmanship and materials
- Work performed in accordance with CSA A23.1
- Does not include the repair of drying shrinkage cracks

Warranty type 2: Extended (Single-Source Approach):

- Two (2) years against defects in the entire floor slab
- Work performed in accordance with CSA A23.1
- Includes the repair of drying shrinkage cracks

Warranty type 3: Performance (Performance Approach):

- Five (5) years against defects in design and floor slab performance

Qualifications and Exclusions:

- Crack repairs for warranty type 2 are based on routing and filling, and not full slab replacement
- Does not include for any repair for drying shrinkage curling (except performance option type 3)
- Does not include repair of defects in work caused by workmanship or materials supplied or performed by others

- Does not include the costs of re-moving and replacing equipment and materials which may be over the remedial work or any costs relating to any loss of use or other consequential damages of having to perform warranty work
- Work to be performed during regular working hours
- Materials manufacturers may offer extended warranties which are separate from the CFCA warranty provided by the concrete floor contractor. Costs relating to the implementation of extended warranties are separately supplied by the materials manufacturer.

Construction

Pre-construction Meetings

Pre-construction meetings have proven valuable in achieving high quality results and avoiding errors. Pre-construction meetings are a critical planning step for all concrete floor installations.

With the traditional “divided-source” approach, it is crucial to bring all parties together to ensure the requirements of the owner are understood. For the “single-source” approach, pre-construction planning is standard practice for all CFCA members. A comprehensive review of the specifications, materials, ambient conditions, specified mock-up samples and floor details should be reviewed at this meeting.

It is common to encounter several aspects which require further consideration including, but not limited to incompatible methods and materials or poor site conditions. The pre-construction meeting must be held on the job site to identify specific challenges that may lie ahead for each project. It is imperative that all parties openly discuss any perceived concerns and address them appropriately.

These meetings should be held approximately one month prior to the commencement of work to allow enough time for the distribution of minutes, submissions, and any reviews or modifications to take place. This affords the owner sufficient time to change sub-contractors, should they be incapable of performing the work correctly due to lack of experience or inability to meet the specified requirements. Holding pre-construction meetings without the necessary planning time can be problematic — concerns may be identified, but making the changes may not be possible.

All project team members should participate in these meetings. This includes the owner’s representative, the general contractor, the concrete floor contractor, the ready mixed concrete supplier, and the inspection and testing company. The involvement of other major material suppliers may also prove helpful. Minutes must be recorded and distributed to all parties in a timely manner, such that any necessary changes can be implemented.

CFCA members will submit the following information as part of the pre-construction meeting process:

- List of materials to be used
- Concrete mix design (when supplied as part of a single-source specification)
- Floor joint layout
- Steel fibre design loading calculations
- Specific concerns or recommendations

Inspection & Testing

Inspection is an integral part of quality control and assurance. Specifiers are urged to employ full-time inspection on concrete pour days to minimize the occurrence of sub-standard work or material substitutions. Due to wide variation of ethical standards, specifiers should assume that they are not getting what they specified without verification through inspection; "you only get what you inspect".

The following items should be inspected for all concrete floor projects:

- Ambient temperatures (air & granular base)
- Granular base elevations within ±10mm
- Benchmark elevation
- Slab thickness
- Verification of the concrete mix on delivery tickets
- Concrete volume used versus theoretical quantity
- Materials supplier names, product designations and dosage application rates for:
    - Fibre reinforcing manufacturer, types and unit weight
    - Concrete mixes including batch time, air content, water slump and final plasticized slump and water:cement ratio
    - Dry shake surface hardeners
    - Sealers and liquid hardeners
    - Curing membranes
    - Joint filler hardness and depth
- Surface tolerances, within 72 hours of slab casting
- Compliance with joint shop drawing

CSA A23.2 Inspection Tests for concrete:

- A23.2–4C Air content of plastic concrete by the pressure method
- A23.2–5C Slump of concrete
- A23.2–6C Density, yield, and cementing materials factor of plastic concrete
- A23.2–16C Standard Test Method for determination of steel or synthetic fibre content in plastic concrete
- A23.2–18C Determination of total water content of normal weight fresh concrete
- A23.2–21C Test Method for length change of hardened concrete

Inspectors must advise regarding any discrepancies when observed on site, in order to facilitate immediate corrective action and avoid compounding errors.

Materials Substitutions

CFCA member firms will not substitute specified products with alternative materials unless approved by the owner's representative.

Corrective & Preventative Action

Concrete floors are manufactured on the jobsite, commonly using a divided-source approach under varying ambient conditions. Under certain circumstances problems may arise which can lead to project complications, such as the wrong concrete mix supplied by others. CFCA member firms are committed to resolving any problems within the boundaries of their contracted scope of work, as in divided-source versus single-source responsibilities.

At the request of specifiers, CFCA representatives will participate in problem resolution efforts on projects which specify the use of CFCA members.

CFCA member firms are required to maintain documentation for all customer complaints. These are retained and can therefore be used to educate the industry about problems and to advise the creation of problem avoidance strategies.

Standard Specification

Table of Contents
Design Considerations
Construction
Standard Specification
Reference & Documents

This guide contains materials, design, and construction recommendation for concrete slabs-on-grade, concrete slabs on metal deck, bonded concrete toppings, and concrete fill to metal pan stairs. Refer also to further technical information available from the CFCA web site at **www.concretefloors.ca/tech.htm**.

Information presented by the Concrete Floor Contractors Association (CFCA) is of a general nature only and is not intended to constitute advice for any specific situation. The reader of this information is to use their own expertise and exercise reasonable diligence in determining the appropriate design, materials, methods or means in carrying out their client's work.

Any technical advice, recommendations, or directions is provided without warranty, either express or implied, and the CFCA assumes no responsibility for errors or omissions. The CFCA shall not be liable in any event for any claims or damages of kind, arising out of, nor in connection with, the use of this information.

If items found in this document are desired by the architect/engineer to be a part of the contract documents, they shall be restated in mandatory language for incorporation by the architect/engineer.

An editable version of the specification is available online: Download document

1 General

1.1 Related Documents

.1 Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to this section. Read notes

1.2 Summary

.1 This section includes all necessary labour, equipment and materials necessary to construct all interior concrete floor slabs on grade, concrete slabs on metal deck, bonded concrete toppings, and concrete fill to metal pan stairs.

.2 Related requirements:

- .1 Formed concrete suspended floor slabs.
- .2 Earthwork, Reinforcing Steel, Miscellaneous Metals and Applied Finishes.
- .3 Mechanical and electrical equipment curbs and pads.
- .4 Applied finish requirements of Division 09.

1.3 References

.1 Abbreviations and Acronyms:

- .1 CFCA – The Concrete Floor Contractors Association, **www.concretefloors.ca**.

.2 Reference Standards:

.1 CSA A23.1–14 Concrete materials and methods of concrete construction.

Read notes

.2 CSA A23.2–14 Test methods and standard practices for concrete.

.3 CSA A23.3–14 (R2010) Design of Concrete Structures.

.4 CSA S413–07 (2012) Parking Structures

.5 ASTM A820 / A820M–16 Standard Specification for Steel Fibers for Fiber-Reinforced Concrete.

.6 ASTM 1064 / 1064M Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.

.7 ASTM C309–11 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

.8 ASTM E1155–14 Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers.

1.4 Administrative Requirements

.1 Concrete Floor Pre-Construction Meeting:

.1 Approximately one month prior to the start of work on site, arrange for a special pre-construction meeting of the Owner's representative, general contractor, testing company, concrete floor trade contractor and specialty material suppliers, in order to review the project drawings, specifications, site conditions, testing procedures, applied finish requirements and any specified mock-up samples so as to permit compliance with the intent of this section.

1.5 Submittals

.1 Action Submittals:

.1 Product Data

.1 The concrete floor contractor shall submit the manufacturer's documentation for each material to be used including:

.1 List of all selected specified materials to be used.

.2 Concrete mix design (when performed as a single-source assembly). Where the concrete mix is supplied by the general contractor as a divided source assembly, the concrete floor contractor shall also receive a copy of the proposed concrete mix design for review and comment.

.3 Floor joint layout and details of isolation, construction and contraction joints.

.4 Steel fibre loading calculations and the Certificate of Compliance and Test Reports as per ASTM A820.

.2 Sustainable Design:

.1 Submit required LEED submittals.

    .3 Any other documents as required by the referenced CSA Standards.

  .2 Informational Submittals:

    .1 Qualification Data: For installation contractor. Read notes

    .2 Minutes of pre-construction conference.

1.6 Quality Assurance

.1 Installation Contractor Qualifications: Read notes

  .1 Single source floor assembly: The following work shall be carried out by a single competent source, being a member of the Concrete Floor Contractors Association, to be responsible to provide the complete concrete floor assembly as specified herein including the supply and installation of concrete materials and all workmanship. The following specialty work shall be performed using the single source approach:

    .1 Exposed architectural concrete finishes

    .2 Ice rink slabs

    .3 Bonded concrete toppings Read notes

  .2 Divided source floor assembly: Concrete placing, finishing, curing and jointing shall be performed by a member of the Concrete Floor Contractors Association.

.2 Source Limitations: Use each type or class of cementitious material of the same brand and from the same manufacturer's plant, maintain aggregates and admixtures from a single source continuously throughout the project. Any source variations are to be reported to the concrete purchaser at least 72 hours before the commencement of any concrete placement.

.3 Concrete Inspection & Testing: the owner shall engage and pay for a qualified and independent testing agency to perform material evaluation and field inspection and testing as required to ensure specification conformance.

.4 Mock Ups:

  .1 Provide a mock-up for the following architectural finishes to demonstrate typical joints, surface finish, texture, tolerances, floor treatments, and standard of workmanship:

    .1 Stained or dyed concrete

    .2 Polished concrete

    .3 Imprinted concrete

    .4 Exposed aggregate concrete Read notes

  .2 Build panel approximately 10 sq. m [100 sq. ft.].

  .3 To reduce waste, approved mock-ups may become part of the completed work or may be installed in areas scheduled to receive other applied finishes as directed by the Consultant.

1.7 Delivery. Storage, and Handling

.1 Deliver, store, and handle materials in a manner that prevents damage. Protect adjacent surfaces from damage resulting from the work of this section.

.2 Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.

1.8 Records

.1 The concrete floor contractor shall keep a written record of each concrete placement including work location, date, ambient air temperature, granular base temperature, volume of concrete placed and any unusual observations .

1.9 Site Conditions

.1 Ensure that the building envelope adequately protects concrete from damage caused by wind, rain, high temperatures, freezing and snow damage. Do not use open flame heaters in the vicinity of fresh concrete. Ensure adequate fresh air ventilation of fumes.

1.10 Warranty Read notes

.1 Divided-source concrete floor assembly shall have a warranty against surface deterioration and dusting for a period of one year from the date of Substantial Performance of the Work.

.2 Single-source concrete floor assembly shall have an extended warranty against surface deterioration, dusting and cracking for a period of two years from the date of Substantial Performance of the Work.

2 Products

2.1 Materials

.1 Concrete slabs on grade scheduled to receive non-breathing finishes shall be placed on a 0.254 mm [10 mils] or greater thickness of vapour retarding membrane. Provide Perminator 10 as manufactured by W.R. Meadows to the extent noted on the project drawings.

.2 Isolation joints around columns and through slab penetrations shall be a minimum of 6 mm [1/4"] thick and made of expanded foam or other compressible filler material.

.3 Isolation joint between the concrete floor slab on grade and the foundation wall shall be polyethylene or waterproof building paper suitable to prevent bonding between the concrete floor and foundation wall.

.4 Bulkheads: Wood or steel.

.5 Dowels: Round or square smooth steel bars or plates with bond breaker on one end to allow horizontal slippage. Plate dowels shall be installed in accordance with the manufacturer's instructions. Construction joints shall be dowelled with smooth non-deformed bars or plates at all locations.

.6 Bonding agent: 2 component epoxy as manufactured by CPD, Euclid, WR Meadows, Sika. Alternatively, an Acrylic or SBR latex bonding agent may be used when approved by the manufacturer (do not use poly-vinyl acetate (PVA)).

.7 Supply steel fibre reinforcing as noted on the project drawings. Steel fibre to be manufactured by ArcelorMittal, Bekaert, Maccaferri, or Optimet. Submit the manufacturer's design load calculations and test data in accordance with ASTM A820. Steel fibres shall be ASTM A820 Type 1 having the following properties:

- Tensile strength of the wire: › 1100 MPa
- Ultimate Strain: ‹ 4%
- Length: › 40 mm
- Aspect Ratio: minimum 44
- Minimum Residual Strength Factor R(e,3) of 30%.

.8 Welded wire mesh shall confirm with ASTM A1064.

.9 Concrete mixes for floors with a trowel finish shall conform to CSA A23.1 having a minimum compressive strength of 25 MPa and a maximum 0.55 water:cement ratio. The concrete shall have an initial water slump of 60 mm [2–3/8"] and final slump of 130 mm [5–1/8"] which shall be obtained through the use of a normal setting water reducing and plasticizing admixture. Concrete ready mixed materials manufacturing shall conform with CRMCA plant certification and ECO requirements as applicable.

.1 Use a concrete mix with a maximum 0.45 water:cement ratio in all areas scheduled to receive a vapour retarding membrane.

.2 Concrete mixes for polished concrete finishes shall be designed to be compatible with the specified aggregate exposure and the system manufacturers instructions.

Read notes

.10 Dry Shake Surface hardeners: Factory pre-mixed [traprock, silica, emery, ferro-silicon, or metallic] aggregates [natural or pigmented] as manufactured by CPD, Euclid or Sika. Location to be as shown on the project drawings. Read notes

.11 Armoured construction joints: Mortar nosing composed of wedge shaped aggregate mortar hardener 75 wide x 12 mm deep at the construction joint edge where exposed to solid tire forklift traffic as noted on project drawings.

.12 Surface Evaporation Reducers: as manufactured by CPD, Euclid or Sika. Follow manufacturers mixing, agitation and application instructions.

.13 Curing compound: Clear, glossy, non-yellowing VOC compliant conforming to ASTM C–309 as manufactured by CPD, Euclid, WR Meadows or Sika.

.14 Polyethylene curing sheet shall be a minimum of 0.05 mm [2 mil] thick.

.15 Liquid silicate densifiers shall be as manufactured by CPD, Duracon, Euclid, WR Meadows or Sika.

.16 Concrete Polishing shall include a liquid silicate densifier and procedures in accordance with the system manufacturers instructions as supplied by CPD, Duracon, Euclid, WR Meadows, Sika.

.17 Acid stains shall be as manufactured by CPD, Increte Systems or Patterned Concrete.

.18 Saw-cut Contraction Joint Fillers: as manufactured by CPD, Euclid, WR Meadows, Sika forming to:

- **.1** Type 1 interior non-vehicular areas: flexible 2 component epoxy/urethane material having a Shore "A" hardness of 25 – 35.
- **.2** Type 2 interior vehicular areas: semi-rigid polyurea or epoxy filler having a minimum Shore "A" hardness of 80.

3 Execution

3.1 Concrete Placement

.1 General Contractor shall ensure adequate temporary lighting as necessary for night time finishing requirements.

.2 Inspect the granular base elevation for variations in excess of +/- 10 mm [3/8"]. Report deviations to the general contractor.

.3 Protect adjacent surfaces from damage or staining as required.

.4 Install vapour retarding membrane in accordance with the manufacturer's instructions. Seal all laps and vertical terminations and repair any damage prior to concrete placement in accordance with manufacturer's instructions. Extend vapour retarder 1000 mm [40"] past the edge of non-breathing finish as noted on the architectural drawings.

.5 Install isolation joint for full slab thickness between free slab edges and perimeter walls wherever the concrete floor is not tied to the foundation wall with rebar.

.6 Wrap through slab penetrations with foam isolation joint or form around penetrations with sonotube for the full depth of the slab. Fill sonotube infills with concrete after 28 days drying or after adjacent saw-cut contraction joints have cracked.

.7 Bulkheads shall be constructed for the full slab thickness, straight and level with the finished floor elevation and shall be located in accordance with the approved joint layout. Dowels shall be installed in the centre of the floor aligned to permit horizontal movement. Do not use deformed rebar for dowels.

.8 Slab thickenings may be pre-poured to reduce drying shrinkage cracking with the approval of the owner.

.9 Add steel fibre reinforcing at the specified rate in accordance with the manufacturer's instructions and CFCA steel fibre installation procedures. No less than the specified dosage rate shall be added to a truckload of concrete in accordance with CSA A23.1.

.10 Install welded wire mesh above the granular base elevation and below the depth of the sawcut contraction joints. Unless otherwise specified, welded wire mesh shall lay directly on the steel deck or precast concrete.

.11 For bonded toppings prepare surfaces, mix and apply bonding agent in accordance with CSA A23.1 and the bonding agent manufacturer's instructions. For latex and cement bonding agents pre-wet surfaces 24 hours prior to topping placement to a saturated surface damp condition.

.12 Place, finish and cure concrete in accordance with CSA A23.1.

.13 Slabs on grade shall be constructed to comply with CSA A23.1 thickness tolerances. The average thickness of all test samples shall be no more than 10mm less than specified. Repair areas more than 20 mm [3/4"] less than specified

.14 Formed suspended slabs and slabs on metal deck shall be screeded to the specified slab thickness without adjustment for camber or deflection.

3.2 Tolerances Read notes

.1 F Number surface tolerances shall be made in accordance with CSA A23.1 and shall be measured within 72 hours of each floor placement. Read notes

.2 Slabs shall meet the following overall F Number tolerances in accordance with CSA A23.1:

- .1 Slabs on grade subject to foot traffic: FF20/FL15
- .2 Slabs on grade with thin floor coverings: FF25/FL20
- .3 Slabs on grade subject to forklift traffic: FF35/FL25
- .4 Slabs on metal deck: FF25
- .5 Formed suspended slabs to receive thick finishes: FF20 Read notes
- .6 Formed suspended slabs to receive thin finishes: FF25

3.3 Liquid Applied Evaporation Reducers

.1 Apply liquid surface evaporation reducers by sprayer to protect the concrete from pre-mature surface drying when using HVSCM and Silica Fume concrete mixes. Mix and agitate in accordance with the manufacturer's instructions. Apply after bull floating and after finishing passes. Do not work evaporation reducer into the surface of the plastic concrete immediately after application.

3.4 Dry Shake Floor Hardeners Read notes

- .1 Apply dry [pigmented] shake surface hardeners in multiple applications, as necessary, to incorporate a coverage rate of ‹__› [3, 5, 7] kg/m^2.

3.5 Imprinted Concrete

.1 Apply colouration, surface texture pattern, borders and accent colours as shown on the project drawings in accordance with the system manufacturer's instructions. Wash and seal to meet approved mock-up sample.

3.6 Exposed Aggregate

.1 Apply a topping of preselected ready mixed concrete aggregates or broadcast specialty aggregates at a rate of 10 kg/m^2 to obtain uniform coverage appearance.

Apply liquid surface retarder as manufactured by CPD, Euclid or Sika. Wash and seal to meet approved mock up and sample.

3.7 Concrete Curing

.1 All surfaces shall be cured commencing as soon as possible after final finishing. Surfaces to be left exposed shall be cured with method 1 or method 2. Bonded toppings and surfaces scheduled to receive penetrating treatments or bonded applied finishes shall be cured with method 2.

.1 Method 1: Curing Membrane – Apply one coat of curing compound evenly across the entire floor surface at the manufacturers recommended coverage rate.

.2 Method 2: Wet Curing – Apply water to the slab surface and cover with polyethylene, burlap or geotextile fabric.

.1 Keep continuously wet for a minimum of 3 days for basic curing period.

.2 Floors subject to forklift traffic shall be wet cured for an additional 4 days.

.3 Bonded toppings shall be continuously wet cured for 7 days with a further 7 day protection period from injurious shock or vibration.

3.8 Contraction Joints in Slab-on-Grade

.1 Sawcut contraction joints shall be installed as shown on the project drawings conforming to with CSA A23.1. Cutting shall commence as soon as possible without damaging the concrete. Read notes

.2 Fill exposed joints subject to solid tire forklift traffic full depth with a load bearing semi-rigid polyurea or epoxy filler (without backer rod) after a minimum 120 days air drying at 20°C. Fill exposed joints subject to foot traffic, with a flexible epoxy/urethane sealant 13 mm [1/2”] deep on a backer rod after a minimum 75 days air drying at 20°C. Fill joints in freezer floors only after the slab has stabilized at operating temperatures. Read notes

3.9 Liquid Penetrating Densifiers

.1 Liquid penetrating densifiers shall be installed by flood coat or spray method in accordance with the manufacturers application instructions. A period of air drying is desirable prior to application.

3.10 Acid Stains and DYES

.1 Apply acid stains and dyes after 28 days of air drying in colours and patterns as shown on the architectural drawings. Apply acid stain in accordance with the manufacturer’s written instructions. Read notes

3.11 Polished Concrete Read notes

.1 Polished Concrete shall be installed in accordance with the system manufacturer’s instructions to meet aggregate exposure Class [A, B or C] and Gloss Level [1, 2, or 3].

.2 Surfaces which will remain exposed shall be protected from staining and spills by the general contractor.

3.12 Field Quality Control

- **.1** Non conforming work shall be repaired to meet the specified requirements.
  Read notes
- **.2** Tests shall be made in accordance with CSA A23.2.
- **.3** Air entrainment and slump testing shall be from the same sample of concrete as the compressive strength cylinders.
- **.4** Materials and workmanship shall be inspected and tested in conformance with CSA A23.1 and CSA A23.2 by an independent inspection company selected and paid for by the Owner.
- **.5** There shall be full time inspection on each concrete floor placement. Inspection reports shall be forwarded to the Owner's representative, the general contractor and the concrete floor contractor. Inspectors shall report any deviations or variations on site immediately to allow for corrective action.
- **.6** Inspection to include for the following:
  - **.1** Verification of benchmark with finished floor elevation.
  - **.2** Verification of Granular base elevation and slab thickness.
  - **.3** Elevation of drains and cleanouts.
  - **.4** Elevation change for sloping floors in relation to drainage.
  - **.5** Inspect placement of reinforcing bars including grade, size, spacing and elevation.
  - **.6** Use of specified materials and dosage or application rates.
  - **.7** Concrete delivery tickets including water:cement ratio, compressive strength, slump and air content at the point of concrete placement. For surfaces to receive a machine trowel finish, the first load of concrete for each placement shall be tested for its plastic air content which shall not exceed 3%.
  - **.8** Concrete compressive strength and plastic air content as per CSA A23.1.
  - **.9** Integrity of vapour retarders including location and sealing of joints and edges as per manufacturers instructions.
  - **.10** Curing regime.
  - **.11** Joint layout.
  - **.12** Joint filler depth.
- **.7** Testing to include the following at the discretion of the Owner:
  - **.1** Concrete drying shrinkage testing.
  - **.2** Fibre washout test as per CSA A23.2 – 16C.
  - **.3** Slab thickness.
  - **.4** F-number floor tolerances (must be measured within 72 hours).

Reference Documents

Definitions

The CFCA defines the following standard terms for use in the concrete floor industry:

Concrete Mix Terminology:

- A "standard" concrete mix is a concrete mix which conforms with the CSA Standard CSA A23.1 Concrete Materials & Methods of Concrete Construction.
- A "compressive strength" concrete mix is a concrete mix which is designed for a defined compressive strength only (without consideration for shrinkage, finishability, permeability, drying time, etc).

Finishability:

As relating to the quality of the cement paste while in a plastic state, from screeding through floating and final trowelling. A surface which has low finishability may have an inadequate amount of portland cement paste, a high water:cement ratio or too high a flyash or slag replacement which can lead to premature surface drying, cracking, bumpy tolerances and delaminations. When concrete mixes are developed for a project, they must also be designed for finishability. (ref: CSA A23.1 Clause 4.1.2.1).

Imprinted Concrete:

Synonyms: stamped, impressed, Increte™, or Patterned™ Concrete. A process of texturing a concrete surface to resemble brick, stone, wood, tile or a variety of other traditional finishes in the surface of a concrete pavement or floor. Imprinted concrete may be natural or pigmented.

Joint Types:

- **Construction Joint:** A joint which is formed to define the limit of a days work and/or to assist in elevation control for screeding.
- **Contraction Joint:** A joint which is normally sawn into newly placed concrete floors to initiate cracking in a defined manner to reduce or eliminate drying shrinkage cracks.
- **Expansion Joint:** A joint sometimes employed in exterior pavements to permit thermal expansion and contraction of the concrete.
- **Isolation Joint:** A joint which extends through the full slab thickness to separate the concrete floor from an adjacent element (eg: a foundation wall).

Liquid Hardeners/Densifiers:

A concrete floor finish for new or old concrete surfaces obtained through the application of a silicate based liquid densifier as specified by the manufacturer. These liquid hardeners react chemically with the hydrated cement paste to chemically densify the surface of the concrete.

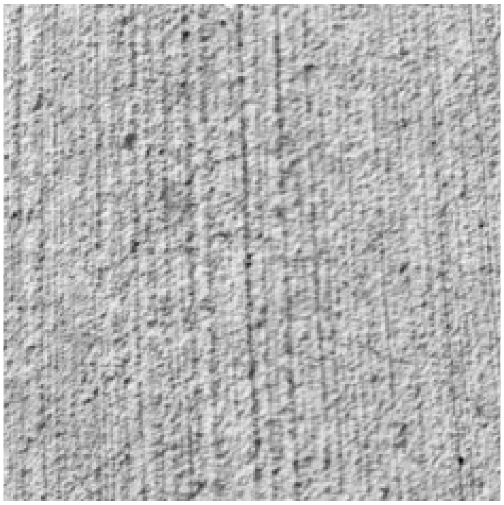
Polished Concrete:

A concrete floor finish for new or old concrete surfaces obtained through intensive diamond grinding, liquid hardener densification of the concrete surface and final diamond polishing to Class A, B, or C and Level 1, 2 or 3.

Standard Concrete Finishes

Broom Finish

- Non-slip



Hand Float "Swirl" Finish

- Finished using hand floats to produce overlapping fan shape
- Non-slip & decorative

Machine Float Finish

- Finished using a trowel machine equipped with float shoes to produce linear circular appearance
- May include variations in uniformity, depending on the concrete set and timing
- Non-slip

Flat Trowel Finish

- Smooth finish with a flat-gloss appearance
- Ideal for surfaces which will receive subsequent applied finishes

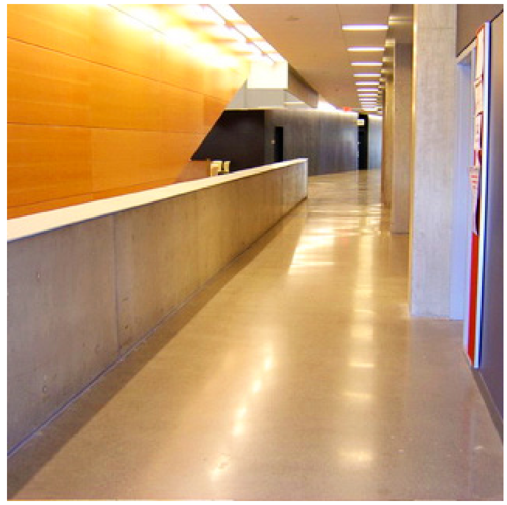
Flat Trowel Finish with Fine Broom

- Flat trowel finish combined with light brooming to obtain fine non-slip finish

Burnished Trowel Finish

- Dense and shiny smooth finish
- Ideal for exposed surfaces and those subject to forklift traffic

Architectural Finish Examples



Polished Concrete

- Plain concrete
- Burnished trowel finish
- Class B Level 2 polished finish with silicate liquid densifier

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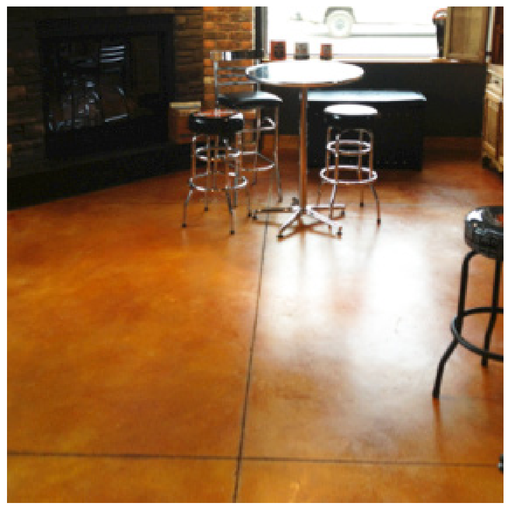


Stained Concrete

- Naturally coloured concrete
- Burnished trowel finish
- Acid stain finish applied to surface using a single colour
- Black sawcut sealant

Stained Concrete

- Naturally coloured concrete
- Burnished trowel finish
- Acid stain finish applied to surface using two colours with a defined pattern (denote patterns on architectural drawings)
- Acrylic sealer

Acid Stain – Multiple Colours

- Naturally coloured concrete
- Burnished trowel finish
- Multiple acid stain colours (denote patterns on architectural drawings)
- Decorative sawcuts between colours
- Acrylic sealer

Black Dye on Light Reflective Hardener

- Light reflective hardener with a flat trowel finish
- Black dye application in square patterns
- Class A Level 2 polished finish with silicate liquid densifier

Imprinted Concrete with Integral Colour

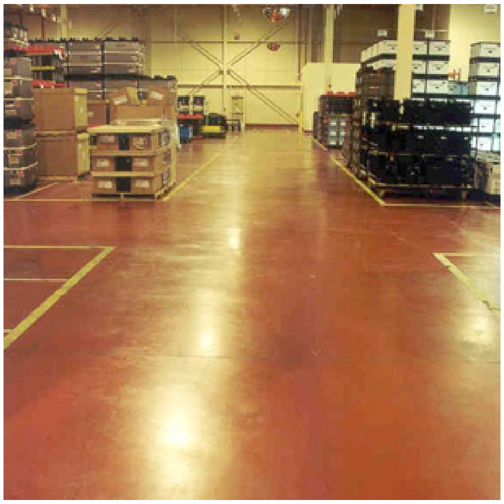
- Small slate texture
- Integrally coloured “C2” concrete with slate imprint and dark grey accent colour
- Acrylic sealer

Imprinted Concrete with Stained Panels

- Naturally coloured “C2” concrete with slate pattern
- Acid stain applied in different colours to alternating slate panels

Surface Hardener – pigmented

- Burnished trowel finish
- Red pigmented surface colour
- Metallic aggregates for high wear resistance
- Wet cured



Light Reflective Floor

- Light reflective dry shake surface hardener
- Flat trowel finish
- Class A Level 2 polished finish with silicate liquid densifier

Deep ground polished concrete with integral colour

- Integral coloured concrete incorporating specialized coarse aggregates and mix design
- Flat trowel finish
- Class C Level 3 polished finish with silicate liquid densifier

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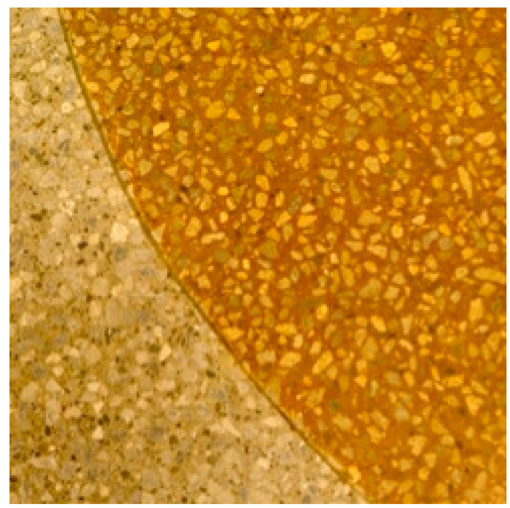

Deep ground polished concrete with integral colour

- Integral coloured concrete incorporating specialized coarse aggregates and mix design
- Flat trowel finish
- Class C Level 3 polished finish with silicate liquid densifier

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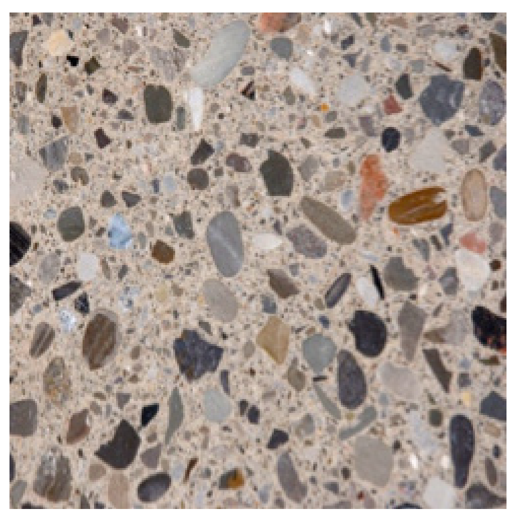
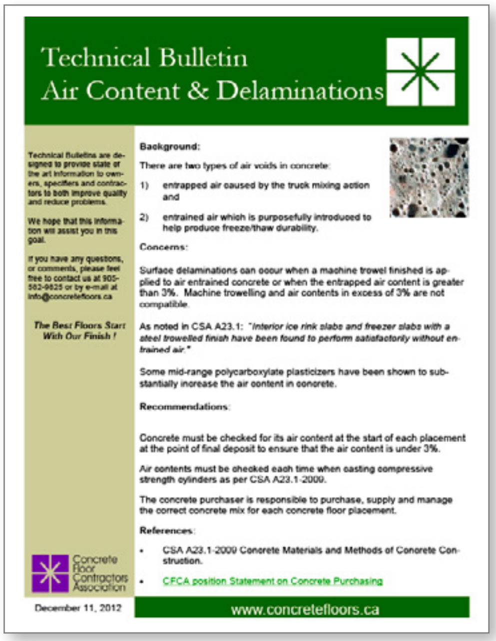


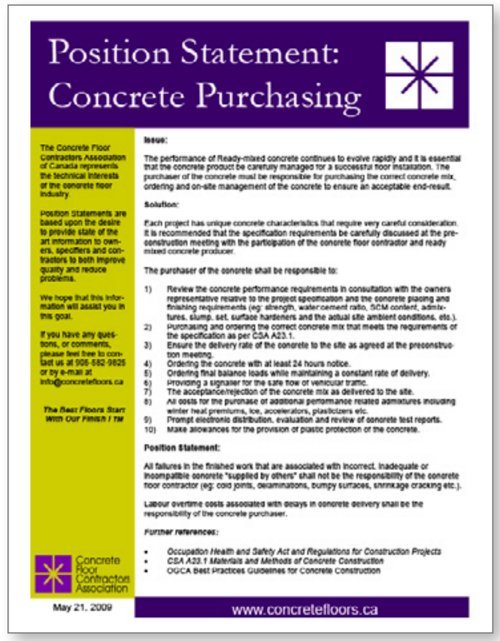
Deep ground polished concrete with natural colour

- Naturally coloured concrete incorporating specialized coarse aggregates and mix design
- Flat trowel finish
- Class C Level 3 polished finish with silicate liquid densifier

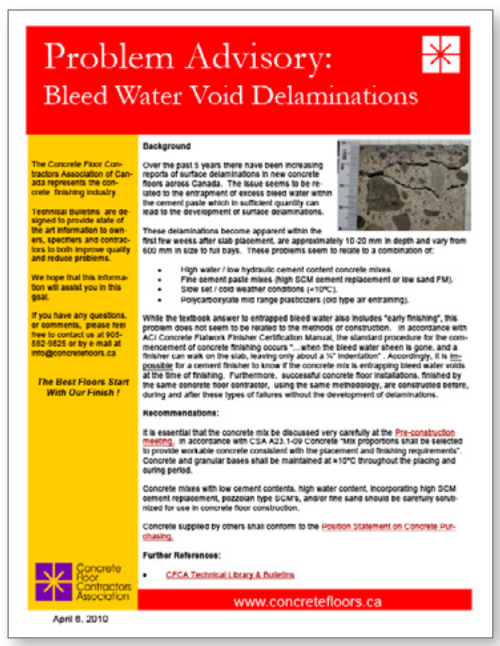
Online Publications

Please click on the following documents to take you to our online resource library (requires an internet connection)


Technical Bulletin
Air Content & Delaminations
December 11, 2012
www.concretefloors.ca


Position Statement:
Concrete Purchasing
May 21, 2009
www.concretefloors.ca


Specification Bulletin
Polished Concrete
Gloss & Aggregate Exposure
April 12, 2011
www.concretefloors.ca


Problem Advisory:
Bleed Water Void Delaminations
April 6, 2010
www.concretefloors.ca

Other Reference Documents

- CSA A23.1–14 Methods and Materials of Concrete Construction
- Add ACI 301-16 “Specifications for Structural Concrete”
- American Concrete Institute (ACI) committee 117–10 “Specification for Tolerances for Concrete Construction and Materials”
- ACI 302.1R–15 “Guide for Concrete Floor and Slab Construction”
- Add ACI 302.2R-06 “Guide for Concrete Slabs that Receive Moisture Sensitive Flooring Materials”
- ACI 360R–10 “Guide to Design of Slabs-on-Ground”
- Material manufacturer’s written instructions
- Occupational Health & Safety Act and Regulations for Construction Projects

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