Russell, Merlin

From: Curtis, Jeff <Jeff.Curtis@safety-kleen.com>
Sent: Tuesday, October 01, 2013 9:53 AM
To: Russell, Merlin
Subject: RE: SK Orange Park Response to NOD
Attachments: Canadian Portland Cement Association Study Information.pdf

Merlin,

I will get the submittal transferred on to a CD and send it out Fedex. I also forgot to include the Canadian Portland Cement Association study so it will also be on the CD, but here it is attached. In addition, I received an e-mail this morning that the Moormann float has been replaced in the HW solvent tank in regards to the NOD item Appendix C Tank Integrity Inspection Report on page 9 of 14.

Thanks,

Jeff Curtis EHS Manager | Safety-Kleen | A Clean Harbors Company | Boynton Beach, FL | jeff.curtis@safety-kleen.com
561.738.3026 (o) | 561.523.4719 (c) | 561.731.1696 (f) | safety-kleen.com

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From: Russell, Merlin [mailto:Merlin.Russell@dep.state.fl.us]
Sent: Tuesday, October 01, 2013 8:39 AM
To: Curtis, Jeff
Subject: SK Orange Park Response to NOD

Jeff,

We did not receive an electronic copy of your submittal. Was one included? If not, would you please send us one? Thanks.

merlin

Merlin D. Russell Jr.
Professional Geologist II
Hazardous Waste Program & Permitting, Room 330G
Florida Department of Environmental Protection
2600 Blair Stone Road
Tallahassee, Florida 32399-2600
850.245.8796 (work)
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Monday-Thursday, 7:00 a.m.-4:30 p.m.; Fridays, 7:00 a.m.-11:00 a.m.

Safety-Kleen ®

RECEIVED
MAR 17 1995

MEMORANDUM

SUBJECT: Epoxy Coatings on Concrete Containment Systems

DEPOT/OFFICE: Breslau

TO: Dan Dowling

DATE: March 2, 1995
H:\ENG\WORD95\CR\CRMEMS.DOC

FROM: Chris Riehl

cc: Peter Dwan
David Flahaut
Frank Wagner

Following continuous problems with the maintenance and high capital cost of epoxy coatings on the concrete containment areas in the branches, I began questioning the need to install these products.

I discussed this issue with the three regional environmental engineers and found the following. In Eastern Canada, only Québec has regulations regarding the requirements for containment areas. Québec Hazardous Waste regulations specify that containment systems have a permeability less than 1×10^{-7} cm/s. In Ontario (Central Region), there are no specific regulations regarding the specifications of containment systems. In Western Region, only B.C. has specific requirements for containment systems, which are the same as Québec. The regulation in B.C. (as attached), also states that the permeability of the containment system must be less than 1×10^{-7} cm/s. Therefore, there are no provincial regulations specifically requiring an epoxy coating system on the concrete containment. However, there are certain branches with permit conditions requiring the coatings.

Preliminary investigations with the Canadian Portland Cement Association (CPCA) revealed the average permeability of concrete is from 1×10^{-10} cm/s (see attached), or one thousand times less permeable than the quantified requirements of Québec and B.C. Following discussions with Peter Dwan, I decided to have laboratory tests done to document this for the files and provide proof for other facilities. The lab tests were done on three core samples taken from the Langley, B.C. branch, and the results are attached. The permeability of the samples ranged from 4.830×10^{-9} cm/s to 1.063×10^{-8} cm/s, falling within the range estimated by CPCA.

In an effort to reduce immediate capital costs and future maintenance cost, I am planning on using this documentation to aggressively fight any agency's requests for the epoxy coatings. I hope this information will also prove useful for the branches in the U.S.

CR/cd

The moisture content of thin concrete elements after drying in air with a relative humidity of 50% to 90% for several months is about 1% to 2% by weight of the concrete depending on the concrete's constituents, original water content, drying conditions, and the size of the concrete element (refer to Chapter 13 for more information).

Size and shape of a concrete member have an important bearing on the rate of drying. Concrete elements with large surface area in relation to volume (such as floor slabs) dry faster than large concrete volumes with relatively small surface areas (such as bridge piers).

Many other properties of hardened concrete also are affected by its moisture content; these include elasticity, creep, insulating value, fire resistance, abrasion resistance, electrical conductivity, and durability.

Strength

Compressive strength may be defined as the measured maximum resistance of a concrete or mortar specimen to axial loading. It is generally expressed in pounds per square inch (psi) at an age of 28 days and is designated by the symbol f'_c. To determine compressive strength, tests are made on specimens of mortar or concrete; in the United States, unless otherwise specified, compression tests of mortar are made on 2-in. cubes, while compression tests of concrete are made on cylinders 6 in. in diameter and 12 in. high (see Fig. 1-6).

Compressive strength of concrete is a primary physical property and one frequently used in design calculations for bridges, buildings, and other structures. Most general-use concrete has a compressive strength between 3000 psi and 5000 psi. High-strength concrete has a compressive strength of at least 6000 psi. Compressive strengths of 20,000 psi have been used in building applications.

In designing pavements and other slabs on ground, the flexural strength of concrete is generally used.

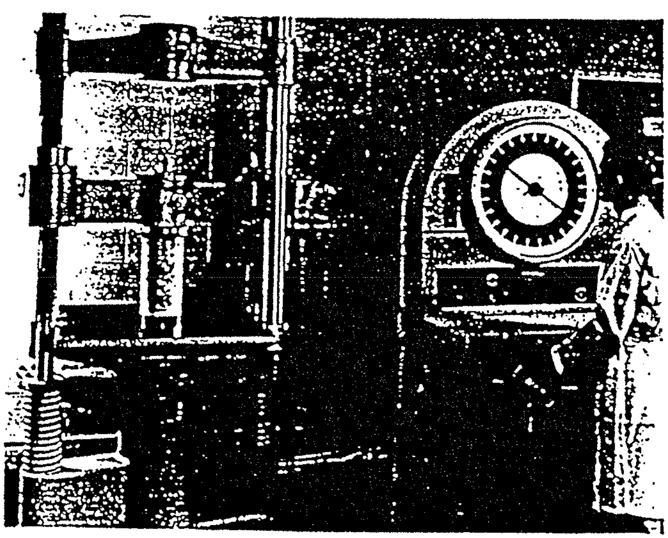

Fig. 1-6. Testing a 6x12-in. concrete cylinder in compression. The load on the test cylinder is registered on the scale.

Compressive strength can be used as an index of flexural strength, once the empirical relationship between them has been established for the materials and the size of the member involved. The flexural strength or modulus of rupture of normal-weight concrete is often approximated as 7.5 to 10 times the square root of the compressive strength.

The tensile strength of concrete is about 8% to 12% of the compressive strength and is often estimated as 5* to 7.5 times the square root of the compressive strength.**

The torsional strength for concrete is related to the modulus of rupture and the dimensions of the concrete element.†

The shear strength of concrete can vary from 35% to 80% of the compressive strength. The correlation between compressive strength and flexural, tensile, torsional, and shear strength varies with concrete ingredients and environment.

Modulus of elasticity, denoted by the symbol E, may be defined as the ratio of normal stress to corresponding strain for tensile or compressive stresses below the proportional limit of a material. For normal-weight concrete, E ranges from 2 to 6 million psi and can be approximated as 57,000 times the square root of the compressive strength.††

The principal factors affecting strength are water-cement ratio and age, or the extent to which hydration has progressed. Fig. 1-7 shows compressive strengths for a range of water-cement ratios at different ages. Tests were made on 6-in.-diameter cylinders that were 12 in. in height. Note that strengths increase with age and increase as the water-cement ratios decrease. These factors also affect flexural and tensile strengths and bond of concrete to steel.

The age-compressive strength relationships in Fig. 1-7 are for typical air-entrained and non-air-entrained concretes. When more precise values for concrete are required, curves should be developed for the specific materials and mix proportions to be used on the job.

For a given workability and a given amount of cement, air-entrained concrete requires less mixing water than non-air-entrained concrete. The lower water-cement ratio possible for air-entrained concrete tends to offset the somewhat lower strengths of air-entrained concrete, particularly in lean-to-medium cement content mixes.

Unit Weight

Conventional concrete, normally used in pavements, buildings, and other structures, has a unit weight in the range of 140 to 150 lb per cubic foot (pcf). The unit weight (density) of concrete varies, depending on the amount and relative density of the aggregate, the amount of air that is entrapped or purposely entrained, and the water and cement contents, which in turn are

*Reference 1-11.
**ACI 207.2R estimates tensile strength as $6.7\sqrt{f'_c}$.
†Torsional strength correlations are presented in Reference 1-11.
††See Section 8.5 of ACI 318.

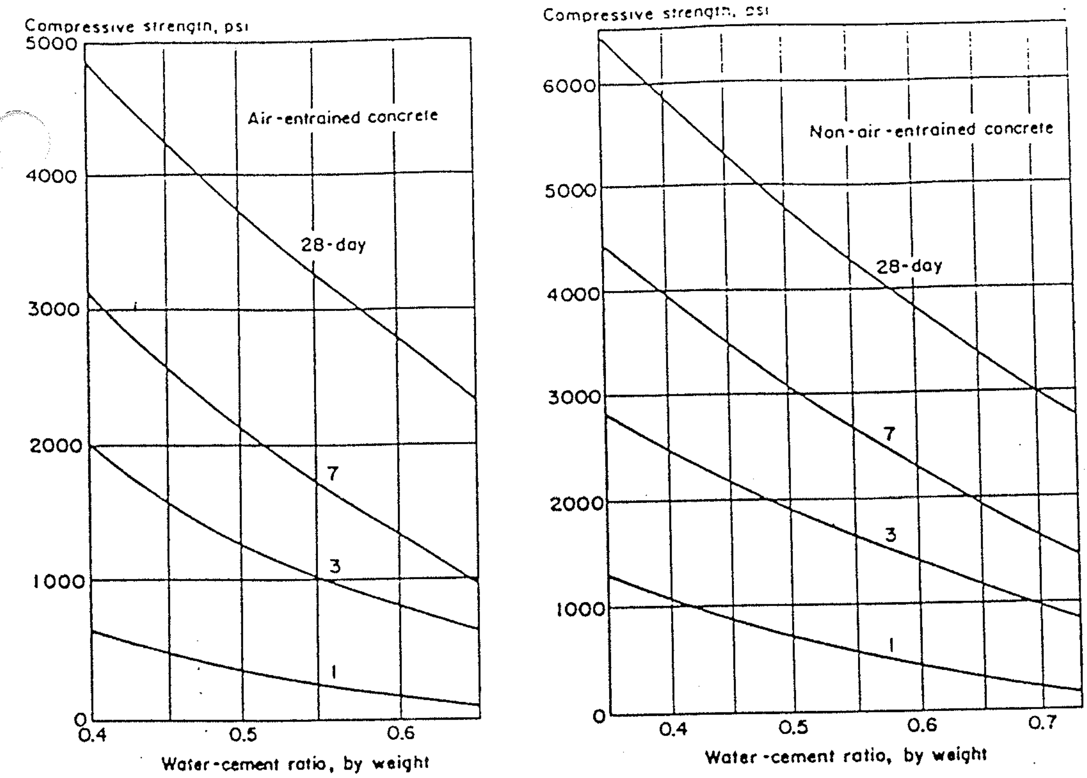

Fig. 1-7. Typical age-strength relationships of concrete based on compression tests of 6x12-in. cylinders, using Type I portland cement and moist-curing at 70°F.

influenced by the maximum-size aggregate. Values of the unit weight of fresh concrete are given in Table 1-1. In the design of reinforced concrete structures, the combination of conventional concrete and reinforcing bars is commonly assumed to weigh 150 pcf.

The weight of dry concrete equals the weight of freshly mixed concrete less the weight of evaporable water. Some of the mix water combines chemically with the cement during the hydration process, converting the cement into cement gel. Also, some of the water remains tightly held in pores and capillaries and does not evaporate under normal conditions. The amount of water that will evaporate in air at 50% relative humidity is about 2% to 3% of the concrete weight, depending on initial water content of the concrete, absorption characteristics of the aggregates, and size of the structure.

Aside from conventional concrete, there is a wide spectrum of other concretes to meet various needs, ranging from lightweight insulating concretes with a unit weight of 15 pcf to heavyweight concrete with a unit weight of up to about 400 pcf used for counterweights or radiation shielding (see Chapter 15, "Special Types of Concrete").

Resistance to Freezing and Thawing

Concrete used in structures and pavements is expected to have long life and low maintenance. It must have good durability to resist anticipated exposure conditions. The most destructive weathering factor is freezing and thawing while the concrete is wet, particularly in the presence of deicing chemicals. Deterioration is caused by the freezing of the water in the paste, the aggregate particles, or both.

With air entrainment, concrete is highly resistant to this deterioration as shown in Fig. 1-8. During freezing,

Table 1-1. Observed Average Weight of Fresh Concrete*

Maximum size of aggregate, inches	Air content, percent	Water, pounds per cubic yard	Cement, pounds per cubic yard	Unit weight, pounds per cubic foot** — Specific gravity of aggregate† 2.55	2.60	2.65	2.70	2.75
¾	6.0	283	566	137	139	141	143	145
1½	4.5	245	490	141	143	146	148	150
3	3.5	204	408	144	147	149	152	154
6	3.0	164	282	147	149	152	154	157

*Source: Reference 1-15, Table 4.
**Air-entrained concrete with indicated air content.
†On saturated surface-dry basis.

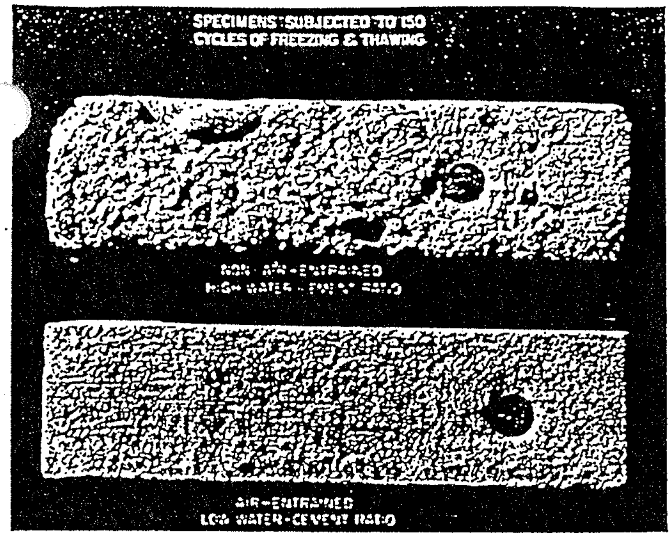

Fig. 1-8. Air-entrained concrete is highly resistant to repeated freeze-thaw cycles.

the water displaced by ice formation in the paste is accommodated so that it is not disruptive; the air bubbles in the paste provide chambers for the water to enter and thus relieve the hydraulic pressure generated.

When freezing occurs in concrete containing saturated aggregate, disruptive hydraulic pressures can also be generated within the aggregate. Water displaced from the aggregate particles during the formation of ice cannot escape fast enough to the surrounding paste to relieve pressure. However, under nearly all exposure conditions, a paste of good quality (low water-cement ratio) will prevent most aggregate particles from becoming saturated. Also, if the paste is air-entrained, it will accommodate the small amounts of excess water that may be expelled from aggregates, thus protecting the concrete from freeze-thaw damage.

Fig. 1-9 illustrates, for a range of water-cement ratios, that (1) air-entrained concrete is much more resistant to freeze-thaw cycles than non-air-entrained concrete, (2) concrete with a low water-cement ratio is more durable than concrete with a high water-cement ratio, and (3) a drying period prior to freeze-thaw exposure substantially benefits the freeze-thaw resistance of air-entrained concrete but does not significantly benefit non-air-entrained concrete.* Air-entrained concrete with a low water-cement ratio and an air content of 4% to 8% will withstand a great number of cycles of freezing and thawing without distress.

Freeze-thaw durability can be determined by laboratory test procedure ASTM C 666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing. From the test, a durability factor is calculated that reflects the number of cycles of freezing and thawing required to produce a certain amount of deterioration. Deicer-scaling resistance can be determined by ASTM C 672, Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals.

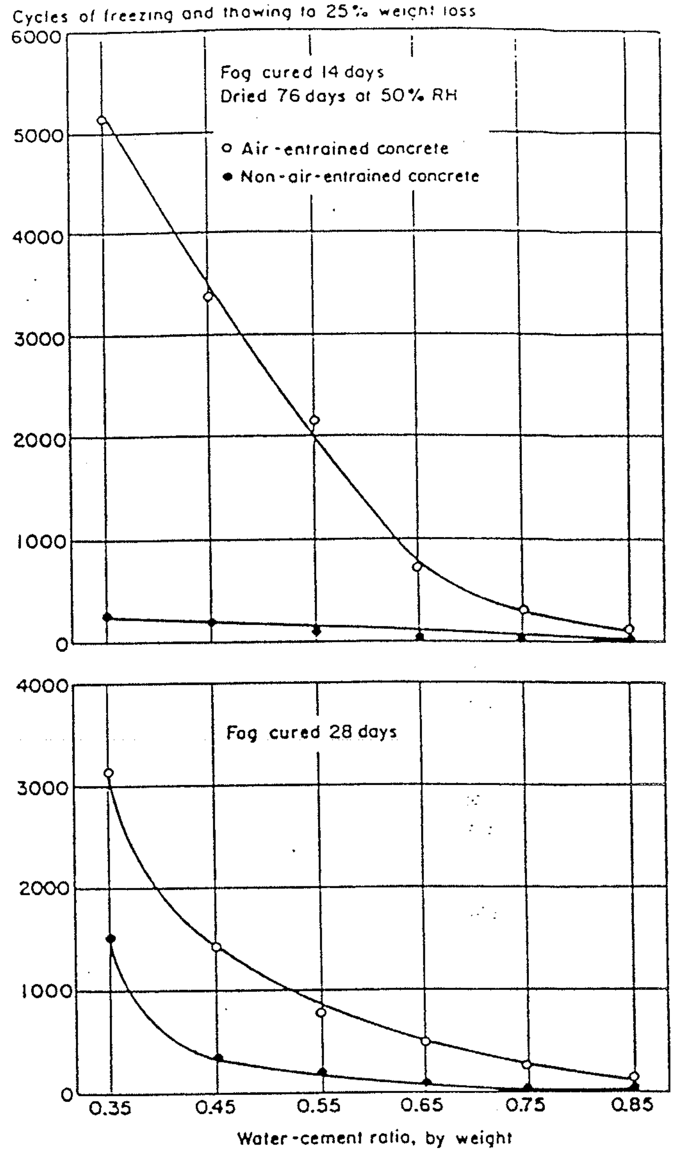

Fig. 1-9. Relationship between freeze-thaw resistance, water-cement ratio, and drying for air-entrained and non-air-entrained concretes made with Type I cement. High resistance to freezing and thawing is associated with entrained air, low water-cement ratio, and a drying period prior to freeze-thaw exposure. Reference 1-5.

Permeability and Watertightness

Concrete used in water-retaining structures or exposed to weather or other severe exposure conditions must be virtually impermeable or watertight. Watertightness is often referred to as the ability of concrete to hold back or retain water without visible leakage. Permeability refers to the amount of water migration through concrete when the water is under pressure or to the ability of concrete to resist penetration of water or other substances (liquid, gas, ions, etc.). Generally,

*See References 1-5 and 1-6.

the same properties of concrete that make concrete less permeable also make it more watertight.

The overall permeability of concrete to water is a function of the permeability of the paste, the permeability and gradation of the aggregate, and the relative proportion of paste to aggregate. Decreased permeability improves concrete's resistance to resaturation, sulfate and other chemical attack, and chloride-ion penetration.

Permeability also affects the destructiveness of saturated freezing. Here the permeability of the paste is of particular importance because the paste envelops all constituents in the concrete. Paste permeability is related to water-cement ratio and the degree of cement hydration or length of moist curing. A low-permeability concrete requires a low water-cement ratio and an adequate moist-curing period. Air entrainment aids watertightness but has little effect on permeability. Permeability increases with drying.*

The permeability of mature hardened paste kept continuously moist ranges from 0.1×10^{-12} to 120×10^{-12} cm per sec. for water-cement ratios ranging from 0.3 to 0.7.* The permeability of rock commonly used as concrete aggregate varies from approximately 1.7×10^{-9} to 3.5×10^{-13} cm per sec. The permeability of mature, good-quality concrete is aproximately 1×10^{-10} cm per sec.

The relationship between permeability, water-cement ratio, and initial curing for 4x8-in. cylindrical concrete specimens tested after 90 days of air drying and subjected to 3000 psi of water pressure is illustrated in Fig. 1-10. The test apparatus is shown in Fig. 1-11. Although permeability values would be different for other liquids and gases, the relationship between water-cement ratio, curing period, and permeability would be similar.

Test results obtained by subjecting 1-in.-thick non-air-entrained mortar disks to 20-psi water pressure are given in Fig. 1-12. In these tests, there was no water leakage through mortar disks that had a water-cement ratio of 0.50 by weight or less and were moist-cured for seven days. Where leakage occurred, it was greater in mortar disks made with high water-cement ratios. Also, for each water-cement ratio, leakage was less as the length of the moist-curing period increased. In disks with a water-cement ratio of 0.80, the mortar still

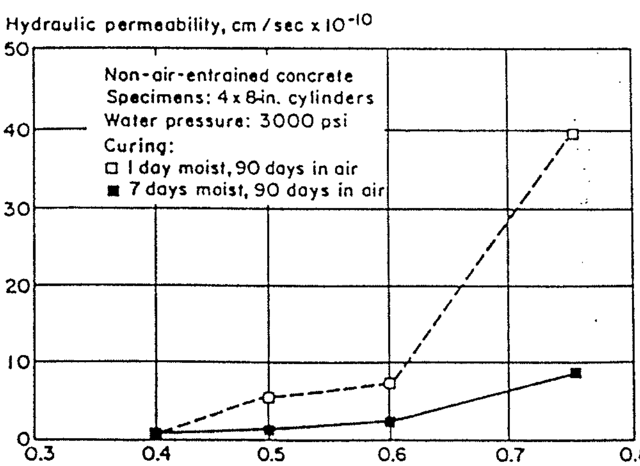

Fig. 1-10. Relationship between hydraulic (water) permeability, water-cement ratio, and initial curing on concrete specimens. Reference PCA HM1170.

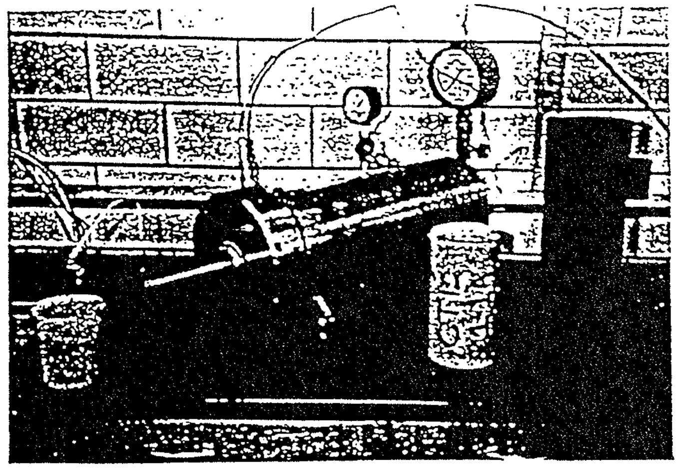

Fig. 1-11. Hydraulic permeability test apparatus used to obtain data illustrated in Fig. 1-10.

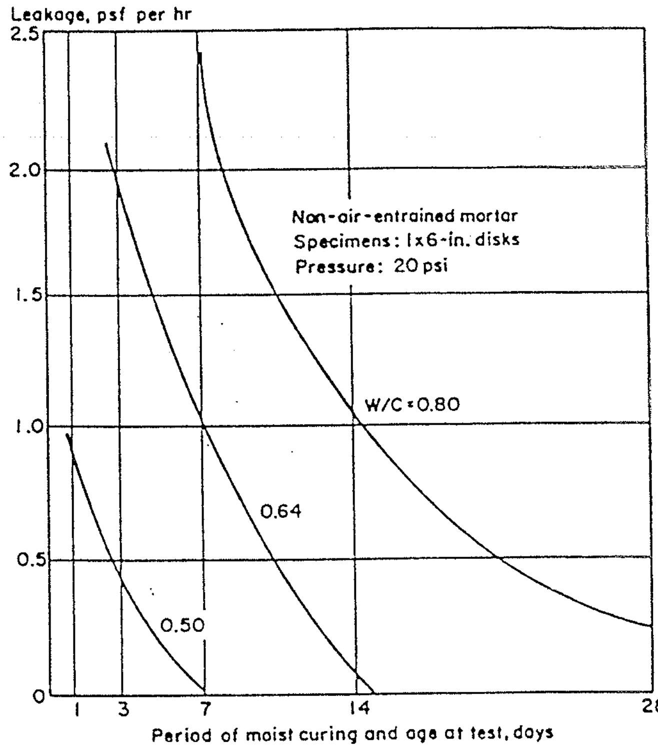

Fig. 1-12. Effect of water-cement ratio (w/c) and curing duration on permeability of mortar. Note that leakage is reduced as the water-cement ratio is decreased and the curing period increased. Reference 1-1 and PCA Major Series 227.

*Reference 1-4.

permitted leakage after being moist-cured for one month. These results clearly show that a low water-cement ratio and a period of moist curing significantly reduce permeability.

A low water-cement ratio also reduces segregation and bleeding, further contributing to watertightness. To be watertight, concrete must also be free from cracks and honeycomb.

Occasionally, porous concrete—no-fines concrete that readily allows water to flow through—is designed for special applications. In these concretes, the fine aggregate is greatly reduced or completely removed producing a high volume of air voids. Porous concrete has been used in tennis courts, pavements, parking lots, greenhouses, and drainage structures. No-fines concrete has also been used in buildings because of its thermal insulation properties. Additional information on porous concrete is given in Chapter 15, "Special Types of Concrete."

Abrasion Resistance

Floors, pavements, and hydraulic structures are subjected to abrasion; therefore, in these applications concrete must have a high abrasion resistance. Test results indicate that abrasion resistance is closely related to the compressive strength of concrete. Strong concrete has more resistance to abrasion than does weak concrete. Since compressive strength depends on water-cement ratio and curing, a low water-cement ratio and adequate curing are necessary for abrasion resistance. The type of aggregate and surface finish or treatment used also have a strong influence on abrasion resistance. Hard aggregate is more abrasion resistant than soft aggregate and a steel-troweled surface resists abrasion more than a surface that is not troweled.

Fig. 1-13 shows results of abrasion tests on concretes of different compressive strengths and aggregate types.

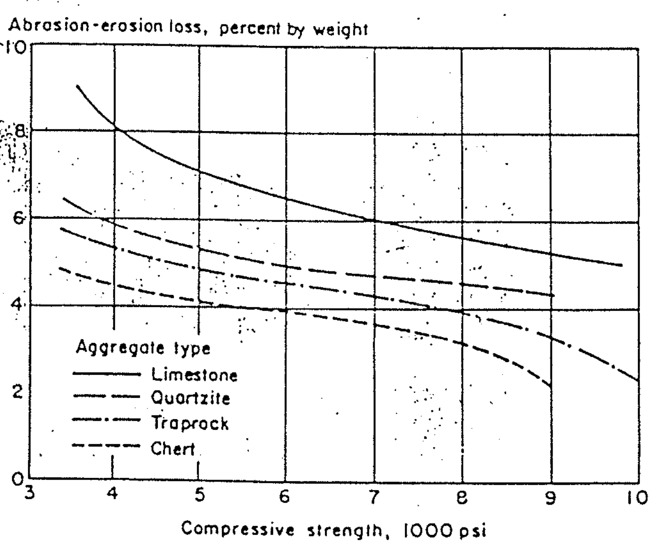

Fig. 1-13. Effect of compressive strength and aggregate type on the abrasion resistance of concrete. High-strength concrete made with a hard aggregate is highly resistant to abrasion. Reference 1-16.

Fig. 1-14 illustrates the effect hard steel troweling and surface treatments have on abrasion resistance. Abrasion tests can be conducted by rotating steel balls, dressing wheels, or disks under pressure over the surface (ASTM C 779). One type of test apparatus is pictured in Fig. 1-15. Other types of abrasion tests are also available (ASTM C 418 and C 944).

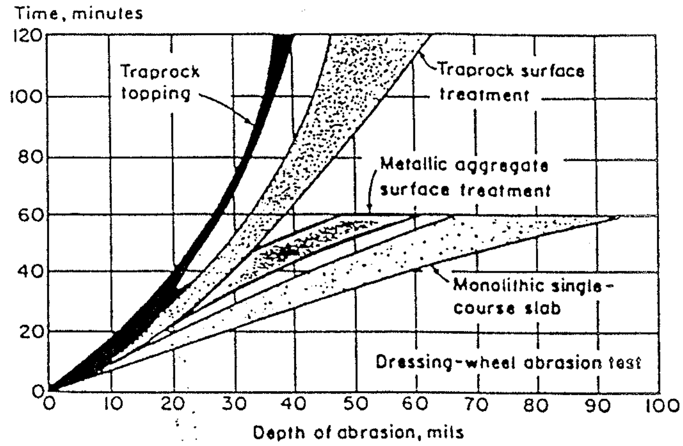

Fig. 1-14. Effect of hard steel troweling and surface treatments on the abrasion resistance of concrete. Base slab compressive strength was 6000 psi at 28 days. All slabs were steel troweled. Reference 1-12.

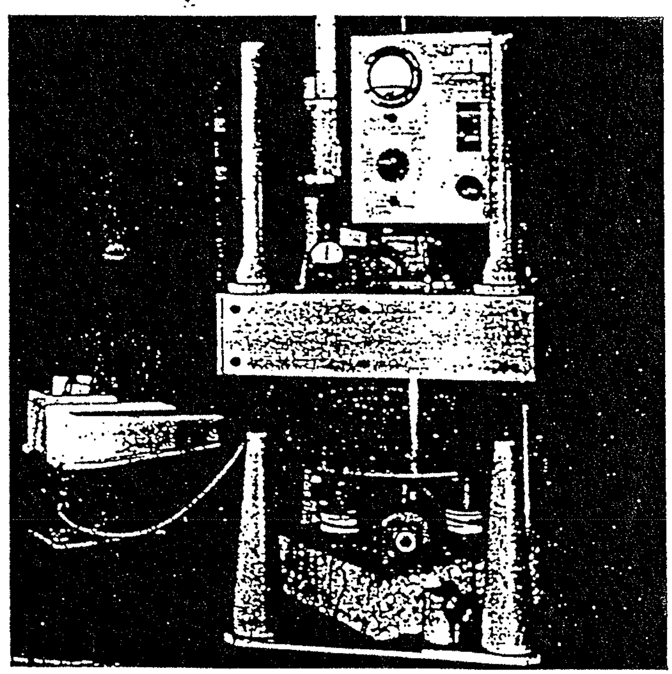

Fig. 1-15. Test apparatus for measuring abrasion resistance of concrete. The machine can be adjusted to use either revolving disks or dressing wheels. With a different machine, steel balls under pressure are rolled over the surface of the specimen. The tests are described in ASTM C 779, Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces.

Volume Stability

Hardened concrete changes volume slightly due to changes in temperature, moisture, and stress. These volume or length changes may range from about 0.01% to 0.08%. Thermal volume changes of hardened concrete are about the same as those for steel.

Concrete kept continually moist will expand slightly. When permitted to dry, concrete will shrink. The primary factor influencing the amount of drying shrinkage is the water content of the freshly mixed concrete. Drying shrinkage increases directly with increases in this water content. The amount of shrinkage also depends upon several other factors, such as amounts of aggregate used, properties of the aggregate, size and shape of the concrete mass, relative humidity and temperature of the environment, method of curing, degree of hydration, and time. Cement content has little to no effect on shrinkage of concrete with cement contents between 5 and 8 bags per cu yd.

Concrete under stress will deform elastically. Sustained stress will result in additional deformation called creep. The rate of creep (deformation per unit of time) decreases with time.

The magnitude of volume changes and factors influencing them are discussed in Chapter 13, "Volume Changes of Concrete."

Control of Cracking

Two basic causes of cracks in concrete are (1) stress due to applied loads and (2) stress due to drying shrinkage or temperature changes in restrained conditions.

Drying shrinkage is an inherent, unavoidable property of concrete; therefore, properly positioned reinforcing steel is used to reduce crack widths, or joints (Fig. 1-16) are used to predetermine and control the location of cracks. Thermal stress due to fluctuations in temperature can cause cracking, particularly at an early age.

Concrete shrinkage cracks occur because of restraint. When shrinkage occurs and there is no restraint, the concrete does not crack. Restraint comes from several sources. Drying shrinkage is always greater near the surface of concrete; the moist inner portions restrain the concrete near the surface, which can cause cracking. Other sources of restraint are reinforcing steel embedded in concrete, the interconnected parts of a concrete structure, and the friction of the subgrade on which concrete is placed.

Joints are the most effective method of controlling unsightly cracking. If a sizable expanse of concrete (a wall, slab, or pavement) is not provided with properly spaced joints to accommodate drying shrinkage and temperature contraction, the concrete will crack in a random manner.*

Control joints are grooved, formed, or sawed into sidewalks, driveways, pavements, floors, and walls so that cracking will occur in these joints rather than in a random manner. Control joints permit movement in the plane of a slab or wall. They extend to a depth of approximately one-quarter the concrete thickness.

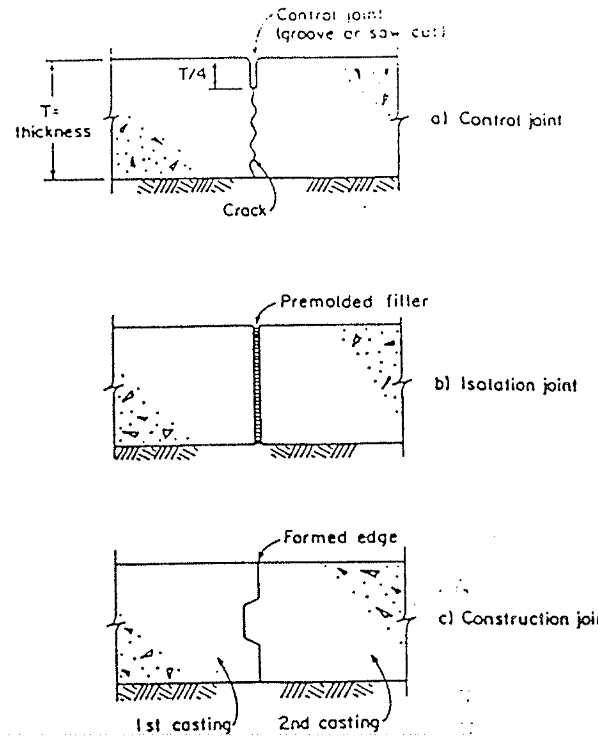

Fig. 1-16. The three basic types of joints used in concrete slab-on-ground construction.

Isolation joints separate a slab from other parts of a structure and permit horizontal and vertical movements of the slab. They are placed at the junction of floors with walls, columns, footings, and other points where restraint can occur. They extend the full depth of the slab and include a premolded joint filler.

Construction joints occur where concrete work is concluded for the day; they separate areas of concrete placed at different times. In slabs-on-ground, construction joints usually align with and function as control or isolation joints.

*Refer to Chapter 9 for more information.

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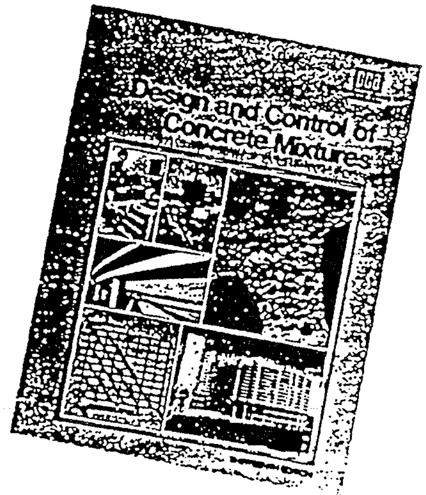
This publication is reprinted from

Design and Control of Concrete Mixtures

13th edition (EB001T), the industry's handbook—for 60 years the ultimate authority on cement and concrete. Here, in one volume, is the complete and up-to-date guide on everything from designing the mix to inspecting the finished product. Topics discussed are as follows:



This 212-page book can be obtained for a nominal charge by writing Portland Cement Association, Order Processing (address below), or by calling 312/966-9559.

Caution: Avoid prolonged contact between unhardened (wet) cement or concrete mixtures and skin surfaces. To prevent such contact, it is advisable to wear protective clothing. Skin areas that have been exposed to wet cement or concrete, either directly or through saturated clothing, should be thoroughly washed with water.

PORTLAND CEMENT ASSOCIATION

An organization of cement manufacturers to improve and extend the uses of portland cement and concrete through market development, engineering, research, education, and public affairs work.

5420 Old Orchard Road, Skokie, Illinois 60077-1083

Reprinted from *Design and Control of Concrete Mixtures* (EB001.13T), Chapter 1.

Fundamentals of Concrete

Concrete is basically a mixture of two components: aggregates and paste. The paste, comprised of portland cement and water, binds the aggregates (sand and gravel or crushed stone) into a rocklike mass as the paste hardens because of the chemical reaction of the cement and water.*

Aggregates are generally divided into two groups: fine and coarse. Fine aggregates consist of natural or manufactured sand with particle sizes ranging up to ⅜ in.; coarse aggregates are those with particles retained on the No. 16 sieve and ranging up to 6 in. The most commonly used maximum aggregate size is ¾ in. or 1 in.

The paste is composed of portland cement, water, and entrapped air or purposely entrained air. Cement paste ordinarily constitutes about 25% to 40% of the total volume of concrete. Fig. 1-1 shows that the absolute volume of cement is usually between 7% and 15% and the water between 14% and 21%. Air content in air-entrained concrete ranges up to about 8% of the volume of the concrete, depending on the top size of the coarse aggregate.

Since aggregates make up about 60% to 75% of the total volume of concrete, their selection is important. Aggregates should consist of particles with adequate strength and resistance to exposure conditions and should not contain materials that will cause deterioration of the concrete. A continuous gradation of particle sizes is desirable for efficient use of the cement and water paste. Throughout this text, it will be assumed that suitable aggregates are being used, except where otherwise noted.

The quality of the concrete depends to a great extent upon the quality of the paste. In properly made concrete, each particle of aggregate is completely coated with paste and all of the spaces between aggregate particles are completely filled with paste, as illustrated in Fig. 1-2.

For any particular set of materials and conditions of curing, the quality of hardened concrete is determined

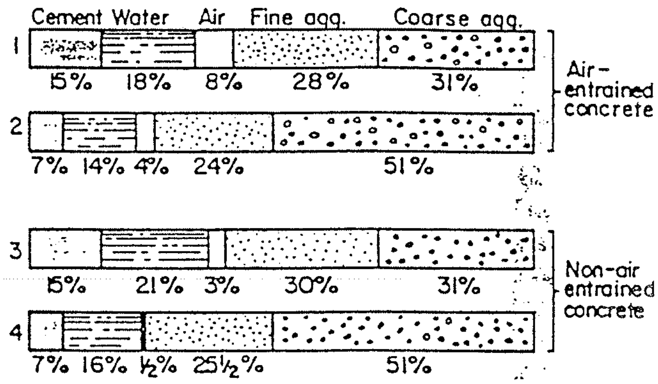


Fig. 1-1. Range in proportions of materials used in concrete, by absolute volume. Bars 1 and 3 represent rich mixes with small aggregates. Bars 2 and 4 represent lean mixes with large aggregates.

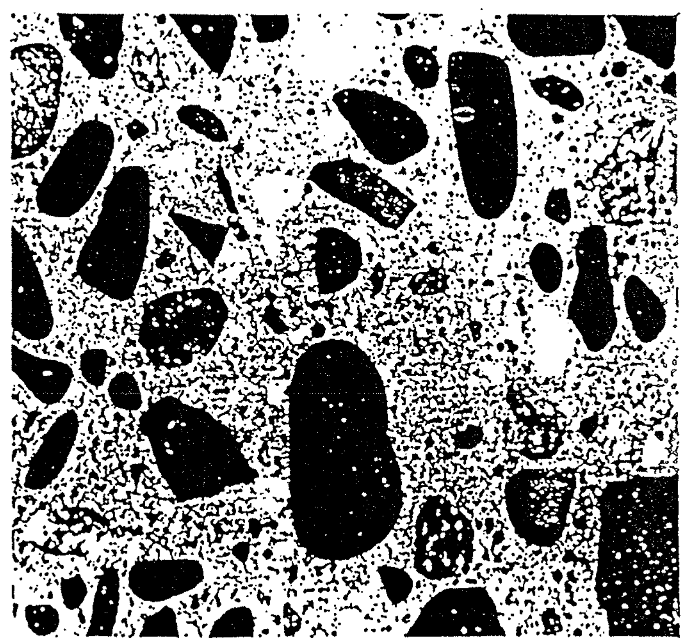


Fig. 1-2. Cross section of hardened concrete. Cement-and-water paste completely coats each aggregate particle and fills all spaces between particles.

*This text addresses the utilization of portland cement in the production of concrete. The term "portland cement" pertains to a calcareous hydraulic cement produced by heating the oxides of silicon, calcium, aluminum, and iron. The term "cement" used throughout the text pertains to portland cement unless otherwise stated.

by the amount of water used in relation to the amount of cement. Following are some advantages of reducing water content:

- Increased compressive and flexural strength
- Lower permeability, thus increased watertightness and lower absorption
- Increased resistance to weathering
- Better bond between successive layers and between concrete and reinforcement
- Less volume change from wetting and drying
- Reduced shrinkage cracking tendencies

The less water used, the better the quality of the concrete—provided it can be consolidated properly. Smaller amounts of mixing water result in stiffer mixtures; but with vibration, the stiffer mixtures can be used. For a given quality of concrete, stiffer mixtures are more economical. Thus consolidation by vibration permits improvement in the quality of concrete and in economy.

The freshly mixed (plastic) and hardened properties of concrete may be changed by adding admixtures to the concrete, usually in liquid form, during batching. Admixtures are commonly used to (1) adjust setting time or hardening, (2) reduce water demand, (3) increase workability, (4) intentionally entrain air, and (5) adjust other concrete properties. Admixtures are discussed in Chapter 6.

After completion of proper proportioning, batching, mixing, placing, consolidating, finishing, and curing, hardened concrete becomes a strong, noncombustible, durable, abrasion-resistant, and practically impermeable building material that requires little or no maintenance. Concrete is also an excellent building material because it can be formed into a wide variety of shapes, colors, and textures for use in almost unlimited number of applications.

FRESHLY MIXED CONCRETE

Freshly mixed concrete should be plastic or semifluid and generally capable of being molded by hand. A very wet concrete mixture can be molded in the sense that it can be cast in a mold, but this is not within the definition of "plastic"—that which is pliable and capable of being molded or shaped like a lump of modeling clay.

In a plastic concrete mixture all grains of sand and pieces of gravel or stone are encased and held in suspension. The ingredients are not apt to segregate during transport; and when the concrete hardens, it becomes a homogeneous mixture of all the components. Concrete of plastic consistency does not crumble but flows sluggishly without segregation.

Slump is used as a measure of the consistency of concrete. A low-slump concrete has a stiff consistency.

In construction practice, thin concrete members and heavily reinforced concrete members require workable, but never soupy, mixes for ease of placement. A plastic mixture is required for strength and for maintaining homogeneity during handling and placement. While a plastic mixture is suitable for most concrete work, superplasticizing admixtures may be used to make concrete more flowable in thin or heavily reinforced concrete members.

Mixing

In Fig. 1-1, the five basic components of concrete are shown separately. To ensure that they are combined into a homogeneous mix requires effort and care. The sequence of charging ingredients into the mixer plays an important part in the uniformity of the finished product. The sequence, however, can be varied and still produce a quality concrete. Different sequences require adjustments in the time of water addition, the total number of revolutions of the mixer drum, and the speed of revolution. Other important factors in mixing are the size of the batch in relation to the size of the mixer drum, the elapsed time between batching and mixing, and the design, configuration, and condition of the mixer drum and blades. Approved mixers, correctly operated and maintained, ensure an end-to-end exchange of materials by a rolling, folding, and kneading action of the batch over itself as the concrete is mixed.

Workability

The ease of placing, consolidating, and finishing freshly mixed concrete is called workability. Concrete should be workable but should not segregate or bleed excessively. Bleeding is the migration of water to the top surface of freshly placed concrete caused by the settlement of the solid materials—cement, sand, and stone—within the mass. Settlement is a consequence of the combined effect of vibration and gravity.

Excessive bleeding increases the water-cement ratio near the top surface and a weak top layer with poor durability may result, particularly if finishing operations take place while bleed water is present. Because of the tendency of freshly mixed concrete to segregate and bleed, it is important to transport and place each load as close as possible to its final position. Entrained air improves workability and reduces the tendency of freshly mixed concrete to segregate and bleed.

Consolidation

Vibration sets into motion the particles in freshly mixed concrete, reducing friction between them and giving the mixture the mobile qualities of a thick fluid. The vibratory action permits use of a stiffer mixture containing a larger proportion of coarse and a smaller proportion of fine aggregate. The larger the maximum-size aggregate in concrete with a well-graded aggregate, the less volume there is to fill with paste and the less aggregate surface area there is to coat with paste; thus less water and cement are needed. With adequate consolidation, harsher as well as stiffer mixtures can be used, resulting in improved quality and economy.

If a concrete mixture is workable enough to be readily consolidated by hand rodding, there may not be an

To: Chris Riehl
From: Peter Swan
Pages: 01
Date: 10/19/94

(c) flammable solids, substances liable to spontaneous combustion or substances that on contact with water emit flammable gases as defined and regulated in Divisions 1, 2 and 3 of Class 4

of the Federal Regulations;

"impervious" means having a permeability not greater than 1×10^{-7} cm per second when subjected to a head of 0.305 m of water;

"incinerator" means a thermal treatment facility using controlled flame combustion;

"incompatible special waste" means a special waste which, when in contact with another special waste or substance and under normal conditions of storage or transportation, may react to produce

(a) heat,

(b) a gas,

(c) a corrosive substance, or

(d) a toxic substance;

"indoor' means enclosed and protected from precipitation and wind as in a building but does not include a shipping container used for passive storage;

"in situ management facility" means a facility used to

(a) prevent or control the movement or release of special waste contaminants, or

(b) treat or destroy special waste contaminants in soil or groundwater

at an historical special waste contaminated site in such a way that the physical location of the special waste contaminants and the soil is not substantially altered.

"labpack" means an outer packaging as defined by the Federal Regulations which has a maximum capacity of 454 ℓ and which is used to transport multiple small inside containers of special waste;

"land treatment" means the treatment of special waste by applying it to land;

"leachate" means any liquid, including suspended materials which it contains, which has percolated through or drained from a special waste facility;

"leachable toxic waste" means waste which when subjected to the Leachate Extraction Procedure described in Part 1 of Schedule 4 produces an extract with a contaminant concentration greater than those prescribed in Table 1 of Schedule 4;

"liner" means a continuous layer of synthetic or natural clay or earth materials, placed beneath and at the sides of a secure landfill, a

** TOTAL PAGE.001 **

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AGAT® Laboratories

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January 23, 1995

RECEIVED JAN 25 1995

Safety-Kleen
300 Woolwich St. S
Breslau, Ontario
N0B 1M0

Attention : Mr. Chris Riehl

Re : Hydraulic Conductivity Study
Our File: 94RE1256

Dear Chris,

Enclosed please find a copy of our report entitled *Hydraulic Conductivity Study* that you requested. Also enclosed is our Invoice #67763 for the amount of $1,363.59.

If you have any questions regarding this study, please do not hesitate to contact us at (403) 299-2000.

Sincerely yours,

AGAT Laboratories

M. Pankalla

Marianna Pankalla, M.Sc.
Reservoir Analyst
Reservoir Engineering Division

299-2105

Graham McLeod

Graham McLeod,P.Geol.,B.Sc.
Manager, Special Core
Reservoir Engineering Division

AGAT Laboratories

CUSTOMER REVIEW

Company:______________________________ Job #:______________

Contact:______________________________ Date:__________ Phone #:______________

1. Type of Work

_____ Routine Core Analysis   _____ Special Core Analysis   _____ Environmental Analysis
_____ Geology/Petrology   _____ Routine Oil, Gas & Water   _____ PVT Analysis
_____ Preventive Maintenance   _____ International   _____ Other

2. Quality of Work

Were the following to your satisfaction? Please check one.

		Exceptional	Good	Needs Improvement
a)	Quality of Results?	______	______	______
b)	Turnaround of Results?	______	______	______
c)	Technical ability of AGAT personnel?	______	______	______
d)	Courtesy by AGAT personnel?	______	______	______
e)	AGAT facilities (ie. core viewing rooms)?	______	______	______
f)	AGAT's presentation of data?	______	______	______
g)	AGAT Salespeople?	______	______	______

3. Would you use AGAT again? Yes______ No______

4. Are there any suggestions as to where you think AGAT might improve their service to you?

____

5. Comments.

____
____
____

These Customer Reviews are extremely important to us here at AGAT. Your well-being and satisfaction are our number one priority. All replies will be held in the strictest confidence.

John Desanti
President

Please send or fax to:
AGAT Laboratories
c/o John Desanti, President
3801 - 21st Street N.E.,
Calgary, AB T2E 6T5,
Fax Number: (403) 299-2005.

HYDRAULIC CONDUCTIVITY STUDY

Prepared for:

SAFETY - KLEEN

Prepared by:

AGAT Laboratories
3801 - 21st Street N.E.
Calgary, Alberta
T2E 6T5

Telephone: (403) 299-2000

Work Order 94RE1245
January, 1995

SUMMARY

For the current study, three (2.5 cm in diameter) cement samples from the West Wall location were subjected to hydraulic conductivity testing.

Prior to testing, samples' petrophysical properties (gas permeability, Boyle's Law porosity and grain density) were determined. The samples were then pressure-saturated with Deionized Water. Each saturated sample was placed in a coreholder and a nominal pressure was applied to the samples to prevent fluid bypass during testing. A hydraulic head of approximately 2.989 kPa (equivalent of 0.305 m of water) was applied to the samples to determine their permeability. The water permeability was calculated from the measured flowrate and hydraulic head applied to the sample. The permeability was then converted to a hydraulic conductivity using a multiplication factor of $9.66*10^{-7}$ cm/s/md.

The hydraulic conductivities of the samples were found to range from $4.830*10^{-9}$ cm/s to $1.063*10^{-8}$ cm/s (refer to Table 1).

SAFETY - KLEEN **FILE 94RE1245**

3 Cement Samples - Hydraulic Conductivity Testing

TABLE 1
SAMPLE SUMMARY

Sample #	Length (cm)	Diameter (cm)	Porosity (%)	Grain Dens (kg/m3)	Gas Perm. (md)	Water Perm. (md)	Hydraulic Conductivity (cm/s)
1	4.673	2.515	22.06	2.584	0.838	0.011	1.06E-08
2	4.936	2.513	16.98	2.596	0.684	0.007	6.80E-09
3	4.711	2.518	13.88	2.712	0.610	0.005	4.83E-09

AGAT Laboratories would like to acknowledge the following employees for their contributions to this report:

Marianna Pankalla, M.Sc.
Reservoir Analyst, Reservoir Engineering Division

Graham McLeod, P.Geol., B.Sc.
Manager, Reservoir Engineering Division

and all Laboratory Technologists

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AGAT LABORATORIES LTD.
Signature [signature]
Date January 10 1995
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The Association of Professional Engineers, Geologists and Geophysicists of Alberta

Report Prepared by : [signature]
Marianna Pankalla, M.Sc.