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LABO S.M. INC.

Longueuil, le 20 novembre 2014

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Objet: Procédure pour vérification quantifiable de la méthode d'analyse MS-55 de Stablex Canada
N/D : F1417261-001

Madame,

Veuillez trouver ci-joints deux (2) copies de notre procédure concernant la vérification quantifiable de la méthode d'analyse MS-55 de Stablex Canada.

Espérant le tout conforme à vos attentes, n'hésitez pas à communiquer avec la soussignée si toutefois des informations additionnelles étaient requises.

Veuillez agréer, Madame, l'expression de nos sentiments les meilleurs.

Isabelle Gauthier, tech. principale
Responsable des opérations de laboratoires – Ingénierie des matériaux

IG/al

p. j. : Procédure *(2 copies)*

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LABO S.M. INC.

PROCÉDURE POUR VÉRIFICATION QUANTIFIABLE MÉTHODE D'ANALYSE MS-55 DE STABLEX CANADA

PRÉSENTÉ À :

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PRÉPARÉ PAR :

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LABO S.M. INC.

1.0 Description du mandat

Établir une procédure de vérification quantifiable de la méthode d'analyse MS-55 de Stablex Canada.

2.0 Établissement de la procédure

Lors d'une rencontre préliminaire nous avons convenu que nous allions soumettre à Stablex Canada une méthode de vérification basée sur les informations transmises lors de cette rencontre. Suivant le dépôt de la méthode préliminaire, Stablex Canada nous a confié le mandat d'établir la procédure conjointement avec leur personnel de laboratoire.

Nous avons testé la procédure préliminaire soumise avec un mélange témoin. Ce mélange nous a permis d'établir la méthode d'échantillonnage en fonction des particularités du mélange de Stablex. Nous avons ensuite modifié notre procédure et donné les différentes instructions au personnel de laboratoire de Stablex Canada pour débuter l'échantillonnage des différentes séries. Étant donné qu'une cure minimale est nécessaire avant de pouvoir tester les spécimens pour la résistance à la compression, aucun spécimen n'a été brisé pendant la phase préliminaire.

Suivant la phase préliminaire, il est convenu d'échantillonner conjointement des échantillons pris selon la méthode MS-55 et des échantillons prélevés selon la méthode d'analyse quantifiable décrite dans ce document.

Cette vérification conjointe nous permettra de confirmer que la méthode d'analyse MS-55 est valide pour confirmer si le produit de Stablex a au moins 100 psi de résistance suivant 56 à 60 jours de cure.

Tous les spécimens ont été échantillonnés en usine par le personnel de laboratoire de Stablex. Ils ont également procédé aux essais et aux manipulations de la méthode d'analyse MS-55 de Stablex Canada. Labo SM inc., a récupéré les différentes séries et a également procédé dans son laboratoire du 2111, boul. Fernand-Lafontaine à Longueuil aux différentes analyses de la méthode proposée.

Pour la validation de la méthode MS-55, 46 séries (mélanges) de 3 spécimens (échantillons) ont été prélevés. Tous les échantillons ont été prélevés sur des lots malaxés entre le 22 avril et le 8 mai 2014, soit sur une période de 3 semaines. Pour chaque série, un échantillon correspondant a été prélevé selon la méthode MS-55 de Stablex Canada. Les spécimens ont été testés avec la méthode proposée par Labo SM inc. suivant une cure variant de 21 à 59 jours, les dates de rupture des différents échantillons ont été choisies par Stablex Canada.

3.0 Présentation de la méthode SM-Stablex 01-2014_v.1

3.1 Étendu

Cette méthode d'analyse permet de quantifier la résistance en compression d'échantillon cylindrique de produit de Stablex ainsi que de déterminer la masse volumique lors de l'échantillonnage de chacun des spécimens soumis à l'essai de résistance à la compression.

3.2 Références

Ministère du développement durable, Environnement et Parcs

Lieux d'enfouissement de sols contaminés
Guide de conception, d'implantation de contrôle et de surveillance
Mars 2012

ASTM C39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimen (*)

La norme ASTM C39 est utilisée comme référence pour l'appareil de compression, la prise des mesures des différents échantillons et le calcul de la résistance en compression.

La presse utilisée pour la résistance en compression correspond, à l'achat, aux différentes caractéristiques physiques de cette norme. La presse est annuellement vérifiée par un tiers selon la norme ASTM E4 tel que spécifié à l'article 5.1.1. de la norme ASTM C39.

Les dimensions des spécimens utilisés pour les analyses sont de 150 mm x 300 mm pour respecter un ratio hauteur diamètre de 2,0. Le diamètre et la hauteur sont mesurés selon l'article 6 de la norme. Les spécimens seront coiffés avec du souffre afin d'aplanir les surfaces pour l'essai de résistance.

Les résultats de résistance à la compression seront calculés selon l'article 8 de la norme.

ASTM D1633 – Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinder (*)

La norme ASTM D1633 est utilisée comme référence normative parce que la résistance et le comportement anticipés des différents échantillons seront similaires à un mélange de sol ciment compacté.

Pour le choix de la dimension des échantillons nous préconisons un ratio de 2 (hauteur-diamètre) tel que décrit dans l'article 4,2 méthodes B de la norme. Selon l'article, le ratio de 2 nous donnera une meilleure mesure de la résistance à la compression.

Pour la mise-en-place un marteau correspondant à l'article 5.2 de la norme sera utilisé. Pour s'adapter à la consistance du produit de Stablex, il sera utilisé comme un pilon, ce sera possible en enlevant le guide du marteau.

Un capteur de force sera utilisé lors de l'essai de résistance à la compression qui correspond à une précision d'au moins 0,04 kN pour la charge appliquée sur les spécimens tel que spécifié à l'article 7.2 de la norme.

Les résultats de résistance en compression pour chaque série prélevée seront exprimés en partie selon les détails de l'article 9 de la norme ASTM D1633 ainsi que d'autres détails pertinents qui s'appliquent au produit de Stablex.

(*)Le mode opératoire est adaptée spécifiquement au produit de Stablex, nous utilisons comme référence les normes ASTM D1633 et ASTM C39/C39M. Étant donné la nature particulière du produit de Stablex aucune de ces deux normes ne peut être appliquée dans son intégralité.

3.3 Équipements

Liste des différents équipements nécessaires pour l'exécution de la méthode :

- Huile à coffrage ou huile minérale;
- Moppe pour l'application de l'huile dans les moules cylindriques;
- Rondelle de papier ciré d'au moins 50 mm de diamètre;
- Moule cylindrique à usage unique de 150 mm x 300 mm avec couvercle;
- Marteau Proctor modifié (sans la gaine);
- Règle à araser d'au moins 300 mm de long avec une arrête biseautée;
- Main d'épicier;
- Balance avec une capacité de 15 kg et une précision de 0,1 g;
- Air comprimée (Démoulage des moules cylindriques);
- Instruments pour la préparation de la surface des éprouvettes;
- Vernier avec une précision de 0,1 mm;
- Presse avec une précision de 0,04 kN;
- Enregistreur de température ambiante;
- Ruban à mesurer 1 mm;

- Contenants nécessaires pour l'échantillonnage en usine.

3.4 Procédure d'échantillonnage dans les moules de 150 mm x 300 mm

3.4.1 Identification

Chaque échantillon de chaque série prélevée dans les moules doit être identifié de façon unique et cette identification doit faire référence à l'échantillonnage correspondant selon la méthode MS-55. En plus de cette identification, chaque échantillon doit avoir les renseignements suivants inscrits sur le moule et sur le formulaire de compilation, soit la date de coulée, la date de rupture et la masse du moule (tare). Inscrire également la masse du moule et du produit de Stablex suivant l'échantillonnage sur le moule, tel qu'illustré par la figure 1.

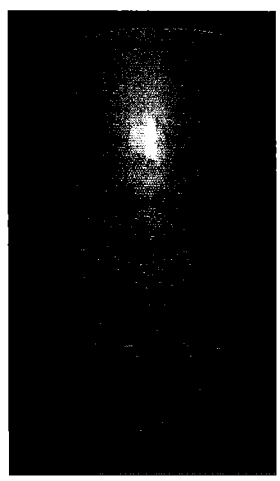

Figure 1

3.4.2 Mise en place dans les moules

Tous les moules cylindriques doivent être perforés au centre du diamètre de la paroi pour avoir une ouverture d'environ 3 mm de diamètre. Cette ouverture permettra le démoulage de l'échantillon avant la rupture.

- Chaque moule doit être huilé avant l'échantillonnage (huile à coffrage ou d'huile minérale). Une rondelle de papier ciré d'au moins 50 mm de diamètre doit être placée au fond du moule pour boucher l'ouverture avant la mise en place du produit de Stablex;
- Prélever le produit de Stablex dans un ou des contenants permettant d'avoir suffisamment de matériel pour combler les trois moules de 150 mm x 300 mm et l'échantillonnage selon la méthode d'analyse MS-55. Enlever les particules trouvées supérieures à 20 mm pour le matériel destiné aux moules de 150 mm x 300 mm;
- Déposer le produit de Stablex dans le moule à l'aide de la main d'épicier suivant chaque dépôt, pilonner le matériel pour le mettre en place afin de combler les vides avec le marteau Proctor modifié. La dernière couche doit être comble;
- Suivant le pilonnage de la dernière couche, araser la surface avec la règle pour obtenir une surface plane;
- Nettoyer l'extérieur du moule puis prendre sa masse et l'inscrire sur le moule et sur le formulaire de compilation Stablex;
- Mettre le couvercle sur le moule.

Suivant l'échantillonnage de la série, déposer délicatement les spécimens à l'endroit désigné pour la cure.

Les échantillons devront être moulés et mis en cure dans un délai maximal de 45 minutes suivant le prélèvement au plan.

3.4.3 Période de cure

Chaque série doit être curée *in situ* jusqu'à l'échéance de la période de cure désirée. Les échantillons ne doivent pas être déplacés durant la cure.

Prendre la température journalière de l'environnement de cure (Facultatif).

3.4.4 Calcul de la masse volumique initiale des échantillons de chacune des séries (MVi)

Suite aux données obtenues lors du prélèvement, calculer la masse volumique initiale de chacun des échantillons de la série.

$$MV_i = M/Vm * 1000\ (kg/m^3)$$

où

M = Masse du moule - tare (g)

et

Vm = Volume approximatif des moules de 150 mm x 300 mm (cm^3) = 5 301,44 cm^3

Inscrire le résultat dans le formulaire de compilation Stablex. Ces données doivent apparaitre dans le tableau récapitulatif des résultats.

3.4.5 Récupération des échantillons destinés à la rupture en compression

Suivant la cure désirée les échantillons sont récupérés et démoulés à l'aide d'air comprimé pour être, ensuite, soumis à l'essai de résistance à la compression.

3.4.6 Résistance à la compression

Chaque échantillon de chacune des séries prélevées sera soumis à un essai de résistance à la compression.

Suivant le démoulage, chaque éprouvette sera mesurée de la manière suivante après l'application de la coiffe (deux mesures de diamètre (mm), deux mesures de hauteur (mm)).

Chaque éprouvette sera mise sous contrainte sur une presse ayant une précision d'au moins 0,04 kN.

Inscrire sur le formulaire désigné les informations suivantes :

- Mesure des diamètres avec une précision de 0,1 mm;
- Mesure des hauteurs avec une précision de 1 mm;
- Mesure du gonflement ou du retrait avec une précision de 1 mm;
- Mesure de la charge en kN;

– Description visuelle de l'état de l'éprouvette avant l'essai.

3.4.7 Photos (Étape facultative)

Suivant chaque rupture chacune des éprouvettes est photographiée.

3.5 Rapport d'analyse et expression final des résultats

3.5.1 Rapport de résistance à la compression

- Identification de la series;
- Date de prélèvement;
- Date de rupture;
- Âge (cure);
- Résistance à la compression avec une précision de 0;01 MPa;
- Résistance à la compression en psi (facultatif);
- Masse volumique lors de l'échantillonnage (kg/m³).

Si le nombre de vérification est élevé, le rapport individuel peut être remplacé par un tableau.

3.5.2 Tableau récapitulatif des données de la méthode MS-55 de Stablex Canada et la méthode SM-Stablex 01-2014 V-1

Un tableau récapitulatif incluant les données suivantes :

SM-Stablex 01-2014 V-1

- Identification de la série;
- Date de prélèvement;
- Date de rupture;
- Âge (cure);
- Résistance à la compression avec une précision de 0,01 MPa;
- Résistance à la compression en psi (facultatif);
- Masse volumique lors de l'échantillonnage (kg/m³).

Compressibilité (MS-55)

- Vérification de la compressibilité;
- Date de la vérification de la compressibilité;
- Âge (cure).

3.5.3 Autres documents

- Températures quotidiennes de cure;
- Rapport photo.

4.0 Étude des résultats d'analyse obtenus dans le cadre du mandat

4.1 Méthode SM-Stablex 01-2014 V-1

4.1.1 Échantillonnage et entreposage des échantillons

Tel que mentionné précédemment les spécimens échantillonnés pour la résistance à la compression sur une presse ont tous été échantillonnés par le personnel de laboratoire de Stablex Canada.

Le peu d'écart observé entre les différentes masses volumiques mesurées lors de l'échantillonnage nous montre clairement que les manipulations ont été bien exécutées et que la méthode est facilement répétable. Ils montrent également que les différents mélanges de Stablex étaient homogènes lors de leur malaxage. L'écart moyen entre les masses volumiques d'une même série est de 9,3 kg/m³ sur des valeurs moyennes par série variant de 1 641 kg/m³ à 1 979 kg/m³.

Les échantillons ont été entreposés chez Stablex Canada durant toute la période de cure de chacun des échantillons. La température moyenne de cure a été de 20,6°C sur une période débutant le 21 avril 2014 et prenant fin le 25 juin 2014. La température minimale enregistrée durant cette période est de 14,5°C et la température maximale est de 25°C. L'annexe 2 donne le détail journalier des températures durant la période d'entreposage.

4.1.2 Résistance à la compression

Suivant les différentes périodes de cure, Labo SM inc. a procédé à la récupération des échantillons, les essais de résistance à la compression ont tous été effectués dans une plage variant de 4 à 30 heures suivant la récupération des échantillons. Les jours de rupture suivant l'échantillonnage ont varié de 29 à 59 jours.

Au total 139 spécimens ont été brisés sur une presse à béton pour obtenir la résistance à la compression.

4.2 *Résumé des résultats d'analyses*

4.2.1 Résumé des résultats d'analyse en fonction du temps de cure.

Vingt (20) spécimens ont été brisés entre 21 et 24 jours de cure, 5 des 20 essais présentent un résultat supérieur à 100 psi. Taux de réussite de 20 %.

Vingt-six (26) spécimens ont été brisés entre 28 et 31 jours de cure, 15 des 26 essais présentent un résultat supérieur à 100 psi. Taux de réussite de 58 %.

Dix (10) spécimens ont été brisés entre 35 et 37 jours de cure, 6 des 10 essais présentent un résultat supérieur à 100 psi. Taux de réussite de 60 %.

Quatre-vingt-un (81) spécimens ont été brisés entre 55 et 59 jours de cure, 50 des 81 essais présentent un résultat supérieur à 100 psi. Taux de réussite de 62 %.

4.2.2 Résumé des résultats en fonction des séries (coulées)

Au total 46 séries ont été contrôlées, chaque série est composée de 3 spécimens.

Vingt (20) des 46 séries ont 3 spécimens qui ont obtenu plus 100 psi de résistance à leur rupture.

Douze (12) des 46 séries ont au moins 1 spécimen ayant obtenu plus 100 psi de résistance à leur rupture.

Quatorze (14) des 46 séries n'ont aucun spécimen ayant une résistance supérieur à 100 psi.

4.2.3 Résumé des résultats en fonction des spécimens

Quatre-vingt-dix-sept (97) spécimens sur 139 présentent un résultat de résistance à la compression supérieur à 100 psi. Soixante-dix pour cent (70 %) des spécimens ont atteint 100 psi en 59 jours ou moins.

4.3 Méthode MS-55

Toutes les manipulations de la Méthode d'analyse MS-55 de Stablex Canada ont été effectuées par le personnel de laboratoire de Stablex Canada. La méthode consiste à vérifier l'enfoncement d'un poids de compression de contrainte déterminée soit 100 psi ou 200 psi et d'indiquer si la pénétration est inférieure ou supérieure à la jauge (au trait) gravé sur la tige du poids de compression.

Des vérifications ont été faites entre 13 et 56 jours de cure.

Suivant 56 jours de cure toutes les séries soumises ont passé le test du poids de compression de 100 psi. Soit une pénétration inférieure à la jauge de l'appareil.

4.4 Validation de la méthode MS-55 par la méthode proposée SM-Stablex 01-2014 V-1 de la résistance à la compression

Pour la validation nous avons vérifié la concordance entre les résultats de résistance à la compression obtenus selon la méthode proposée et la méthode MS-55.

Selon les résultats obtenus la méthode proposée validerait 26 séries (coulée) sur les 46 séries contrôlées. Dans les 20 autres cas nous avions des résultats passant le test avec la méthode MS-55 mais les valeurs obtenues selon la méthode proposée nous donnaient des résultats inférieurs à 100 psi.

5.0 Conclusion

La méthode proposée SM-Stablex 01-2014 V-1, a été utilisée pour la première fois dans le cadre de ce mandat et nous avons dû faire quelques ajustements en cours de route qui ont pu affecter certains résultats, nous considérons que la méthode proposée est valable.

Cependant, les résultats obtenus dans les conditions de contrôle préconisés pour le mandat, ne permettent pas de valider la méthode MS-55 avec la méthode quantitative proposée (SM-Stablex 01-2014 V-1).

Nous croyons que la rupture en compression prématurée de certains spécimens et la validation par une des deux méthodes selon des cures différentes ne nous permet pas de conclure hors de tout doute que la méthode MS-55 est valide ou non.

Nous émettons aussi des réserves sur le récipient utilisé dans la méthode MS-55, nous croyons celui-ci trop petit et croyons que la proximité du rebord pourrait influencer le comportement du poids de contrôle lors de la vérification.

6.0 Recommandations

Nous recommandons une deuxième phase d'analyse en tenant compte des recommandations suivantes :

- Faire un plan de rupture à la compression à des jours de cures spécifiés et de faire les vérifications avec les 2 méthodes en simultané, soit pas plus de 72 heures de différences entre les 2 vérifications;
- Étant donnée la faible résistance à la compression anticipée du produit de Stablex, nous recommandons 28 jours de cure minimale avant d'effectuer une rupture à la compression selon la méthode proposée;
- Nous recommandons également que les échantillons soient double pour s'assurer d'un certain contrôle analytique et s'assurer d'avoir au moins une valeur de résistance suivant un nombre de jour de cure spécifique pour une série.
- Introduire une 2^{e} méthode de validation quantitative inspirée de l'essai de résistance au cône suédois. (si possible);
- Consigner la description visuelle des échantillons au montage et lors de la rupture en compression pour permettre d'isoler les coulées problématiques.
- Faire certains échantillons de Stablex selon la méthode MS-55 en double dans le contenant habituel et dans un contenant plus grand que ceux utilisés présentement, nous vous proposons au moins 100 mm de diamètre.

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ANNEXE 1

RÉSULTATS : TABLEAU RÉCAPITULATIF

	Échantillonnage				Validation statistique de l'échantillonnage		Méthode MS-55			Rupture à la compression Labo SM Inc.					Qualification de l'état des éprouvettes		Status		
	Coulées (Identification)	Date de coulée	Échantillon	Masse volumique (kg/m³)	Masse volumique (kg/m3) Moyenne	Écart moyen	Compressibilité théorique (PSI)	Date de la vérification	Cure (jour)	Date de rupture	Cure (jour)	Résistance à la compression (MPa)	Résistance à la compression (PSI)	Masse volumique corrigée (Suite aux changements de volume) (kg/m³)	Gonflement (mm)	Relevé des déficiences et remarques particulières	Validé	Non validé	Différence de cure entre les 2 méthodes (jour)
1	1123-C	2014-04-22	1	1718	1713	5	100/200	2014-05-21	29	2014-05-29	37	1.10	159.54	1712	1		1		1
			2	1706						2014-05-22	30	0.83	116.00	1706	0				
			3	1715						2014-05-22	30	0.86	130.50	1715	0				
2	1124-C	2014-04-22	1	1766	1774	6	100/200	2014-05-21	29	2014-06-19	58	1.81	262.52	1766	0		1		8
			2	1779						2014-05-29	37	1.69	245.11	1773	1				
			3	1778						2014-06-19	58	2.44	353.89	1761	3				
3	1131-C	2014-04-23	1	1639	1641	5	100/200	2014-05-21	28	2014-06-19	57	0.47	68.17	1633	1	2- Délamination		1	8
			2	1649						2014-05-29	36	0.29	42.06	1633	3				
			3	1636						2014-06-19	57	0.55	79.77	1631	1				
4	1132-C	2014-04-23	1	1713	1716	3	100/200	2014-05-21	28	2014-06-19	57	0.97	140.69	1713	0	2- Délamination	1		29
			2	1715						2014-05-29	36	0.34	49.31	1710	1				
			3	1720						2014-06-19	57	0.89	129.08	1720	0				
5	1133-C	2014-04-23	1	1831	1830	5	100/200	2014-05-21	28	2014-05-29	36	1.03	149.39	1831	0	1- Mal consolidé, pas homogène 3- Mal consolidé, pas de lecture	1		1
			2	1822						2014-05-22	29	0.63	91.37	1822	0				
			3	1837						2014-05-22	29	0	0	1837	0				
6	1134-C	2014-04-23	1	1804	1781	15	100/200	2014-05-21	28	2014-05-29	36	1.74	252.37	1792	2		1		8
			2	1768						2014-06-19	57	2.32	336.49	1768	0				
			3	1772						2014-06-19	57	2.18	316.18	1772	0				
7	1135-C	2014-04-23	1	1690	1681	9	100/200	2014-05-21	28	2014-06-19	57	1.82	265.42	1690	0		1		29
			2	1672						2014-06-19	57	1.41	204.50	1672	0				
			3							**									
8	1141-C	2014-04-24	1	1746	1738	6	100/200	2014-05-21	27	2014-06-19	56	2.19	317.63	1740	1		1		8
			2	1732						2014-06-19	56	2.12	307.48	1732	0				
			3	1735						2014-05-29	35	1.05	152.29	1729	1				
9	1142-C	2014-04-24	1	1811	1814	8	100/200	2014-05-21	27	2014-05-29	35	0.42	60.92	1788	4			1	8
			2	1804						2014-06-19	56	0.87	126.18	1798	1				
			3	1827						2014-06-19	56	0.95	137.79	1815	2				
10	1143-C	2014-04-24	1	1705	1702	3	100/200	2014-05-26	32	2014-05-29	35	0.25	36.26	1650	10			1	3
			2	1703			0	2014-05-21	27	2014-06-19	56	0.33	47.86	1675	5				
			3	1698						2014-05-22	28	0.2	29	1670	5				
11	1144-C	2014-04-24	1	1725	1704	14	100/200	2014-05-21	27	2014-06-19	56	0.83	120.38	1702	4	1- Milieu du cylindre, fissuré, 2- Mauvaise consolidation	1		8
			2	1691						2014-05-29	35	0.86	124.73	1637	10				
			3	1695						2014-06-19	56	1.03	149.39	1678	3				
12	1151-C	2014-04-25	1	1689	1702	9	100/200	2014-05-21	26	2014-06-19	55	0.5	72.52	1661	5			1	29
			2	1711						2014-06-19	55	0.5	72.52	1694	3				
			3	1706						**				1694	2				
13	1181-C	2014-04-28	1	1791	1770	14	100/200	2014-05-21	23	2014-05-29	31	1.34	194.35	1762	5	1- Délamination	1		8
			2	1761						2014-06-26	59	1.4	203.05	1732	5				
			3	1758						2014-05-29	31	1.13	163.89	1718	7				
14	1182-C	2014-04-28	1	1751	1749	2	100/200	2014-05-21	23	2014-06-26	59	1.45	210.30	1728	4		1		8
			2	1750						2014-06-26	59	1.78	258.17	1744	1				
			3	1747						2014-05-29	31	1.44	208.85	1718	5				
15	1183-C	2014-04-28	1	1783	1796	9	100/200	2014-05-21	23	2014-05-22	24	1.31	190.00	1765	3		1		1
			2	1802						2014-05-22	24	1.56	226.26	1773	5				
			3	1803						2014-05-29	31	1.72	249.46	1779	4				
16	1184-C	2014-04-28	1	1835	1833	3	100/200	2014-05-21	23	2014-06-26	59	2.16	313.28	1829	1		1		8
			2	1828						2014-06-26	59	2.45	355.34	1822	1				
			3	1834						2014-05-29	31	1.29	187.10	1822	2				

	Échantillonnage				Validation statistique de l'échantillonnage		Méthode MS-55			Rupture à la compression Labo SM Inc.					Qualification de l'état des éprouvettes		Status		
	Coulées (Identification)	Date de coulée	Échantillon	Masse volumique (kg/m³)	Masse volumique (kg/m3) Moyenne	Écart moyen	Compressibilité théorique (PSI)	Date de la vérification	Cure (Jour)	Date de rupture	Cure (Jour)	Résistance à la compression (MPa)	Résistance à la compression (PSI)	Masse volumique corrigée (Suite aux changements de volume) (kg/m³)	Gonflement (mm)	Relevé des déficiences et remarques particulières	Validé	Non validé	Différence de cure entre les 2 méthodes (jour)
17	1185-C	2014-04-28	1	1817	1819	2	100/200	2014-05-21	23	2014-06-26	59	1.92	278.42	1830	-2	1 - Ressuage (volume du spécimen inférieur au volume du moule)	1		8
			2	1819						2014-06-26	59	2.11	306.03	1812	1				
			3	1822						2014-05-29	31	1.45	210.30	1810	2				
18	1191-C	2014-04-29	1	1797	1808	7	100/200	2014-05-21	22	2014-06-26	58	1.95	282.82	1785	2		1		8
			2	1811						2014-06-26	58	1.89	274.12	1793	3				
			3	1814						2014-05-29	30	1.13	163.89	1785	5				
19	1192-C	2014-04-29	1	1799	1798	1	100/200	2014-05-21	22	2014-05-29	30	1.07	155.19	1799	0		1		8
			2	1796						2014-06-26	58	1.81	262.52	1796	0				
			3	1798						2014-06-26	58	1.45	210.30	1735	11				
20	1193-C	2014-04-29	1	1750	1751	2	100/200	2014-05-21	22	2014-06-26	58	1.69	245.11	1733	3		1		8
			2	1755						2014-05-29	30	1.13	163.89	1755	0				
			3	1747						2014-06-26	58	1.46	211.76	1747					
21	1194-C	2014-04-29	1	1804	1797	8				2014-05-29	30	0.26	37.71	1804	0		1		3
			2	1802			0	2014-05-21	22	2014-06-26	58	0.72	104.43	1802	0				
			3	1785			100/200	2014-06-24	55	2014-06-26	58	0.66	95.72	1785	0				
22	1195-C	2014-04-29	1	1745	1751	6				2014-05-29	30	0.01	1.45	1745	0	2, 3- Pas de prise initiale		1	3
			2	1748			0	2014-05-21	22	2014-05-22	23	0.01	1.40	1748	0				
			3	1759			100/200	2014-06-24	55	2014-06-26	58	0.25	36.26	1759	0				
23	1201-C	2014-04-30	1	1672	1675	5				2014-05-29	29	0.02	2.90	1672	0	1- Pas de prise initiale, déformation		1	3
			2	1670			0	2014-05-21	21	2014-06-26	57	0.24	34.81	1670	0				
			3	1682			100/200	2014-06-24	54	2014-06-26	57	0	0.00	1682	0				
24	1202-C	2014-04-30	1	1685	1687	12	100/200	2014-05-21	21	2014-06-26	57	1.16	168.24	1685	0	1, 2- Beaucoup de vide, 3- Mal consolidé	1		8
			2	1672						2014-06-26	57	1.06	153.74	1661	2				
			3	1706						2014-05-29	29	0.95	137.79	1678	5				
25	1203-C	2014-04-30	1	1750	1749	5	100/200	2014-05-21	21	2014-06-26	57	0.62	89.92	1750	0			1	8
			2	1742						2014-05-29	29	0.33	47.86	1742	0				
			3	1756						2014-06-26	57	0.7	101.53	1738	3				
26	1204-C	2014-04-30	1	1977	1979	5				2014-05-29	29	0.01	1.45	1977	0	3- Pas de prise initiale, déformé		1	2
			2	1987			50	2014-05-21	21	2014-06-26	57	0.3	43.51	1987	0				
			3	1975			100/200	2014-06-24	55	2014-05-22	22	0	0	1975	0				
27	1205-C	2014-04-30	1	1917	1916	3	100/200	2014-05-21	21	2014-06-26	57	0.41	59.47	1917	0	2- Délamination		1	8
			2	1912						2014-05-29	29	0.22	31.91	1912	0				
			3	1921						2014-06-26	57	0.36	52.21	1921	0				
28	1211-C ***	2014-05-01	1	1729	1714	10	100/200	2014-05-21	20	2014-06-26	56	0.41	59.47	1689	7			1	8
			2	1709						2014-06-26	56	0.7	101.53	1681	5				
			3	1705						2014-05-29	28	0.45	65.27	1650	10				
29	1212-C ***	2014-05-01	1	1727	1734	5	100/200	2014-05-21	20	2014-06-26	56	0.95	137.79	1721	1	2- Déformé, 3- Pas de prise initiale		1	8
			2	1733						2014-05-29	28	0.39	56.56	1733	0				
			3	1741						2014-06-26	56	1.04	150.84	1729	2				
30	1213-C	2014-05-01	1	1678	1678	2	100/200	2014-05-21	20	2014-05-22	21	0.77	111.7	1624	10		1		1
			2	1681						2014-05-29	28	0.7	101.53	1627	10				
			3	1675						2014-05-22	21	0.77	111.7	1637	7				
31	1214-C	2014-05-01	1	1756	1771	16	100/200	2014-05-21	20	2014-06-26	56	1.62	234.96	1733	4	3- Beaucoup de vide	1		8
			2	1796						2014-05-29	28	0.98	142.14	1755	7				
			3	1762						2014-06-26	56	1.57	227.71	1744	3				
32	1215-C	2014-05-01	1	1781	1770	7	100/200	2014-05-21	20	2014-05-29	28	1.23	178.4	1775	1		1		8
			2	1764						2014-06-26	56	2.02	292.98	1764	0				
			3	1766						2014-06-26	56	1.93	279.92	1755	2				

	Échantillonnage				Validation statistique de l'échantillonnage		Méthode MS-55			Rupture à la compression Labo SM Inc.					Qualification de l'état des éprouvettes		Status		
	Coulées (Identification)	Date de coulée	Échantillon	Masse volumique (kg/m³)	Masse volumique (kg/m3) Moyenne	Écart moyen	Compressibilité théorique (PSI)	Date de la vérification	Cure (Jour)	Date de rupture	Cure (Jour)	Résistance à la compression (MPa)	Résistance à la compression (PSI)	Masse volumique corrigée (Suite aux changements de volume) (kg/m³)	Gonflement (mm)	Relevé des déficiences et remarques particulières	Validé	Non validé	Différence de cure entre les 2 méthodes (Jour)
33	1251-C	2014-05-05	1	1706	1700	6	100/200	2014-05-21	16	2014-05-29	24	0.4	58.02	1689	3	2- Échantillons avec la même identification	1		8
			1	1706						2014-07-03	59	59	175.5	1689	3				
			2	1695						2014-05-29	24	0.64	92.82	1684	2				
			3	1692						2014-07-03	59	1	145.04	1681	2				
34	1252-C	2014-05-05	1	1664	1673	6	100/200	2014-05-21	16	2014-07-03	59	1.51	219	1637	5	2- Déformé	1		8
			2	1677						2014-05-29	24	0.85	123.28	1607	13				
			3	1678						2014-07-03	59	1.7	246.56	1656	4				
35	1253-C	2014-05-05	1	1695	1694	2	100/200	2014-05-21	16	2014-07-03	59	0.6	87.02	1689	1	3- Vides		1	8
			2	1697						2014-05-29	24	0.29	42.06	1669	5				
			3	1690						2014-07-03	59	0.85	123.28	1690	0				
36	1254-C	2014-05-05	1	1667	1673	9	100/200	2014-05-21	16	2014-05-29	24	0.48	69.62	1588	15			1	8
			2	1686						2014-07-03	59	0.86	124.73	1664	4				
			3	1665						2014-07-03	59	0.72	113.13	1643	4				
37	1261-C ***	2014-05-06	1	1665	1665	3				2014-07-03	58	0.27	39.16	1687	-4	2 et 3- Pas de prise initiale		1	2
			2	1669			0	2014-05-21	15	2014-05-29	23	0.02	2.9	1669	0				
			3	1661			100/200	2014-07-02	56	2014-07-03	58	0.25	36.26	1661	0				
38	1262-C	2014-05-06	1	1849	1848	8	100/200	2014-07-02	56	2014-07-03	58	0.72	104.43	1717	23	3- Pas de prise initiale, ovale	1		2
			2	1860			0	2014-05-21	15	2014-07-03	58	0.54	78.32	1771	15				
			3	1835						2014-05-29	23	0.01	1.45	1721	20				
39	1263-C	2014-05-06	1	1747	1745	6				2014-05-29	23	0	0	1674	13	1- Pas de prise initiale, déformation		1	2
			2	1752			0	2014-05-21	15	2014-07-03	58	0.27	39.16	1712	7				
			3	1735			100/200	2014-07-02	56	2014-07-03	58	0.33	47.86	1735	0				
40	1264-C	2014-05-06	1	1681	1680	8	100/200	2014-05-21	15	2014-05-29	23	0.23	33.36	1566	22			1	8
			2	1668						2014-07-03	58	0.38	55.11	1584	16				
			3	1690						2014-07-03	58	0.3	43,51	1610	15				
41	1271-C	2014-05-07	1	1644	1644	2				2014-07-03	57	0.62	89.92	1541	20	2- Pas de prise initiale		1	2
			2	1641			0	2014-05-21	14	2014-05-29	22	0.29	4.06	1543	19				
			3	1646			100/200	2014-07-02	55	2014-07-03	57	0.61	88.47	1557	17				
42	1272-C	2014-05-07	1	1723	1724	7	100/200	2014-07-02	55	2014-07-03	57	0	0	1689	6	3- Pas de prise initiale		1	2
			2	1735			0	2014-05-21	14	2014-07-03	57	0	0	1706	5				
			3	1715						2014-05-29	22	0.02	2.9	1660	10				
43	1273-C	2014-05-07	1	1669	1669	4	100/200	2014-05-21	14	2014-07-03	57	0.5	72,52	1615	10			1	8
			2	1662						2014-05-29	22	0.26	37.71	1583	15				
			3	1674						2014-07-03	57	0.47	68.17	1636	7				
44	1274-C	2014-05-07	1	1639	1638	2	100/200	2014-05-21	14	2014-07-03	57	0.52	75.42	1601	7			1	8
			2	1641						2014-07-03	57	0.6	87.02	1614	5				
			3	1634						2014-05-29	22	0.33	47.86	1582	10				
45	1281-C	2014-05-08	1	1657	1656	5	100/200	2014-07-02	54	2014-07-03	56	1.48	214.66	1651	1		1		2
			2	1661			0	2014-05-21	13	2014-07-03	56	1.56	226.26	1650	2				
			3	1649						2014-07-03	56	1.33	192.9	1649	0				
46	1282-C	2014-05-08	1	1706	1721	10				2014-05-29	21	0.42	60.92	1630	14	1- Pas homogène, 2- Pas de prise initiale	1		2
			2	1733			0	2014-05-21	13	2014-07-03	56	0.66	95.72	1699	6				
			3	1723			100/200	2014-07-02	54	2014-07-03	56	0.76	110.23	1631	17				

*** Présence de beaucoup de tissu et de plastique.
** La production n'a pas remplie les chaudières: le 3ième cylindre n'était pas rempli.

SM*i*

LABO S.M. INC.

ANNEXE 2

TEMPÉRATURE DE CURE

SM*i* LABO S.M. INC.

Stablex
Température de cure
F1417261001

15009	Time	Celsius(°C)	Serial Number
1	21/04/2014 12:05:38	24	4611
2	22/04/2014 00:05:38	24	
3	22/04/2014 12:05:38	23.5	
4	23/04/2014 00:05:38	25	
5	23/04/2014 12:05:38	22.5	
6	24/04/2014 00:05:38	18	
7	24/04/2014 12:05:38	16.5	
8	25/04/2014 00:05:38	17.5	
9	25/04/2014 12:05:38	16.5	
10	26/04/2014 00:05:38	17.5	
11	26/04/2014 12:05:38	17	
12	27/04/2014 00:05:38	17	
13	27/04/2014 12:05:38	14.5	
14	28/04/2014 00:05:38	17	
15	28/04/2014 12:05:38	17	
16	29/04/2014 00:05:38	18	
17	29/04/2014 12:05:38	17	
18	30/04/2014 00:05:38	18	
19	30/04/2014 12:05:38	18	
20	01/05/2014 00:05:38	17	
21	01/05/2014 12:05:38	16	
22	02/05/2014 00:05:38	18	
23	02/05/2014 12:05:38	18	
24	03/05/2014 00:05:38	16.5	
25	03/05/2014 12:05:38	16.5	
26	04/05/2014 00:05:38	17.5	
27	04/05/2014 12:05:38	17.5	
28	05/05/2014 00:05:38	17	
29	05/05/2014 12:05:38	17	
30	06/05/2014 00:05:38	17.5	
31	06/05/2014 12:05:38	16.5	
32	07/05/2014 00:05:38	18	
33	07/05/2014 12:05:38	17.5	
34	08/05/2014 00:05:38	18	
35	08/05/2014 12:05:38	18	
36	09/05/2014 00:05:38	19.5	
37	09/05/2014 12:05:38	19	
38	10/05/2014 00:05:38	20	
39	10/05/2014 12:05:38	20.5	
40	11/05/2014 00:05:38	21	
41	11/05/2014 12:05:38	21	

SM^i LABO S.M. INC.

Stablex
Température de cure
F1417261001

15009	Time	Celsius(°C)	Serial Number
42	12/05/2014 00:05:38	20	
43	12/05/2014 12:05:38	21	
44	13/05/2014 00:05:38	19	
45	13/05/2014 12:05:38	19.5	
46	14/05/2014 00:05:38	19.5	
47	14/05/2014 12:05:38	19	
48	15/05/2014 00:05:38	19.5	
49	15/05/2014 12:05:38	21	
50	16/05/2014 00:05:38	22.5	
51	16/05/2014 12:05:38	21.5	
52	17/05/2014 00:05:38	21	
53	17/05/2014 12:05:38	19.5	
54	18/05/2014 00:05:38	18.5	
55	18/05/2014 12:05:38	17.5	
56	19/05/2014 00:05:38	17.5	
57	19/05/2014 12:05:38	17.5	
58	20/05/2014 00:05:38	18.5	
59	20/05/2014 12:05:38	18.5	
60	21/05/2014 00:05:38	19.5	
61	21/05/2014 12:05:38	19.5	
62	22/05/2014 00:05:38	20	
63	22/05/2014 12:05:38	21	
64	23/05/2014 00:05:38	19.5	
65	23/05/2014 12:05:38	19.5	
66	24/05/2014 00:05:38	19.5	
67	24/05/2014 12:05:38	19.5	
68	25/05/2014 00:05:38	20	
69	25/05/2014 12:05:38	19.5	
70	26/05/2014 00:05:38	21	
71	26/05/2014 12:05:38	21.5	
72	27/05/2014 00:05:38	21.5	
73	27/05/2014 12:05:38	21.5	
74	28/05/2014 00:05:38	17.5	
75	28/05/2014 12:05:38	19.5	
76	29/05/2014 00:05:38	19.5	
77	29/05/2014 12:05:38	19	
78	30/05/2014 00:05:38	20.5	
79	30/05/2014 12:05:38	20.5	
80	31/05/2014 00:05:38	21.5	
81	31/05/2014 12:05:38	21	
82	01/06/2014 00:05:38	21	

SM*i* LABO S.M. INC.

Stablex
Température de cure
F1417261001

15009	Time	Celsius(°C)	Serial Number
83	01/06/2014 12:05:38	21.5	
84	02/06/2014 00:05:38	21.5	
85	02/06/2014 12:05:38	22.5	
86	03/06/2014 00:05:38	23	
87	03/06/2014 12:05:38	25	
88	04/06/2014 00:05:38	24.5	
89	04/06/2014 12:05:38	22.5	
90	05/06/2014 00:05:38	21.5	
91	05/06/2014 12:05:38	21	
92	06/06/2014 00:05:38	21.5	
93	06/06/2014 12:05:38	21	
94	07/06/2014 00:05:38	22.5	
95	07/06/2014 12:05:38	23	
96	08/06/2014 00:05:38	24	
97	08/06/2014 12:05:38	23.5	
98	09/06/2014 00:05:38	24.5	
99	09/06/2014 12:05:38	25	
100	10/06/2014 00:05:38	24.5	
101	10/06/2014 12:05:38	24	
102	11/06/2014 00:05:38	24	
103	11/06/2014 12:05:38	24	
104	12/06/2014 00:05:38	24.5	
105	12/06/2014 12:05:38	21	
106	13/06/2014 00:05:38	21	
107	13/06/2014 12:05:38	22	
108	14/06/2014 00:05:38	22	
109	14/06/2014 12:05:38	22.5	
110	15/06/2014 00:05:38	21.5	
111	15/06/2014 12:05:38	21.5	
112	16/06/2014 00:05:38	22.5	
113	16/06/2014 12:05:38	22.5	
114	17/06/2014 00:05:38	22.5	
115	17/06/2014 12:05:38	22.5	
116	18/06/2014 00:05:38	23.5	
117	18/06/2014 12:05:38	22	
118	19/06/2014 00:05:38	24.5	
119	19/06/2014 12:05:38	24	
120	20/06/2014 00:05:38	23.5	
121	20/06/2014 12:05:38	23.5	
122	21/06/2014 00:05:38	22	
123	21/06/2014 12:05:38	22.5	

SMi LABO S.M. INC.

Stablex
Température de cure
F1417261001

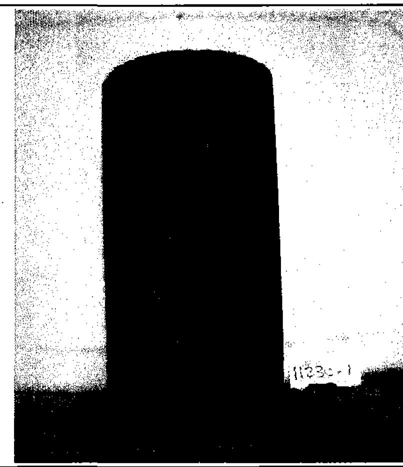
15009	Time	Celsius(°C)	Serial Number
124	22/06/2014 00:05:38	22.5	
125	22/06/2014 12:05:38	22	
126	23/06/2014 00:05:38	23	
127	23/06/2014 12:05:38	23.5	
128	24/06/2014 00:05:38	24	
129	24/06/2014 12:05:38	25	
130	25/06/2014 00:05:38	24.5	
131	25/06/2014 12:05:38	23.5	
	Moyenne	20.6	
	Min	14.5	
	Max	25.0	

SM*i*

LABO S.M. INC.

ANNEXE 3

RAPPORT PHOTOS

Série 1123C		
		
Échantillon 1	Échantillon 2	Échantillon 3
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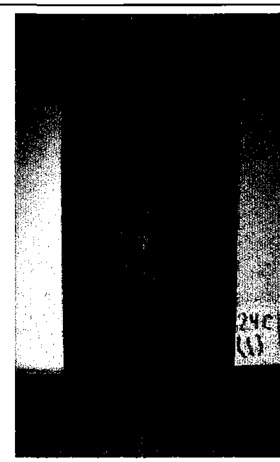	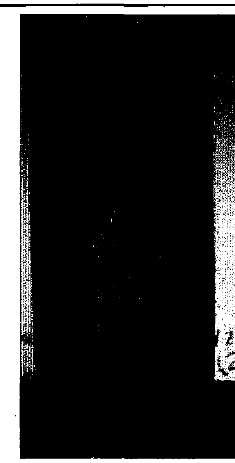	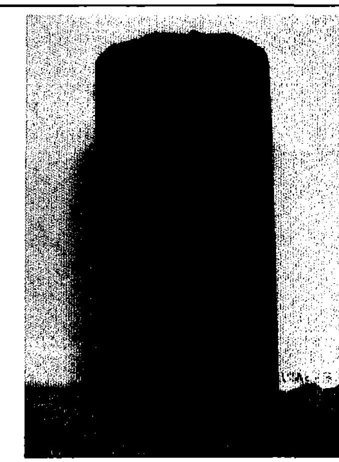
Échantillon 1	Échantillon 2	Échantillon 3

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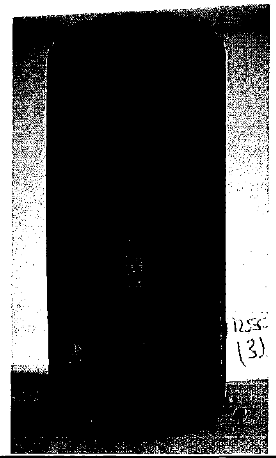	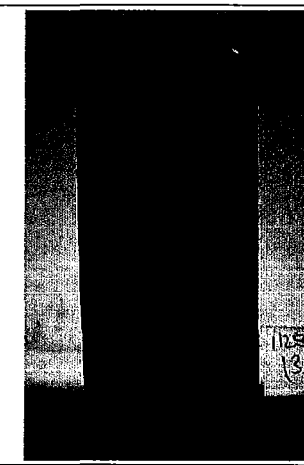
Échantillon 1	Échantillon 2

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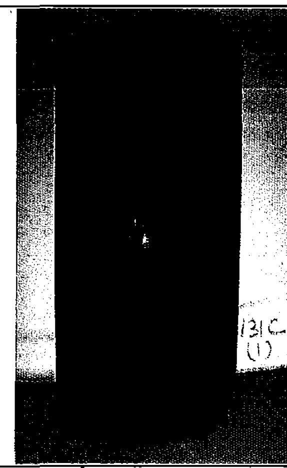	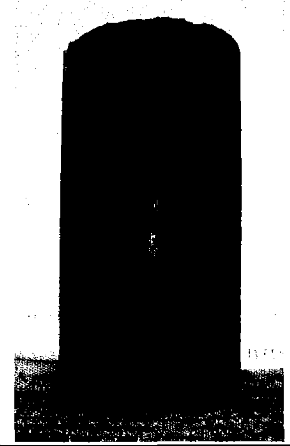	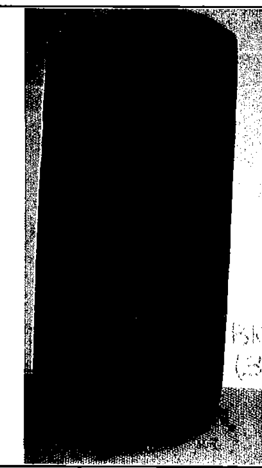
Échantillon 1	Échantillon 2	Échantillon 3

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	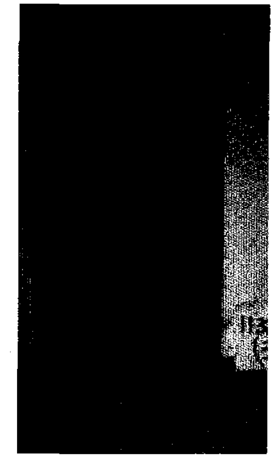
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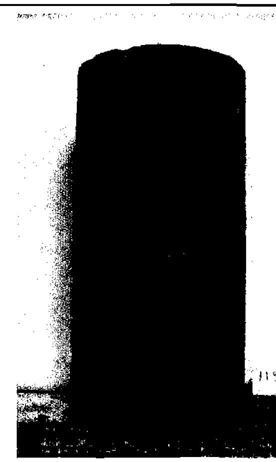	
Échantillon 1	**Échantillon 3**

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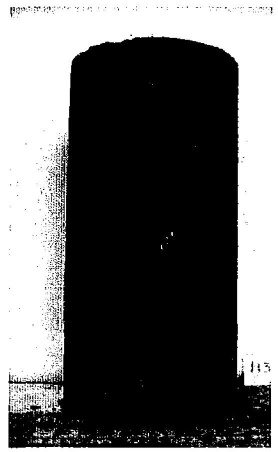
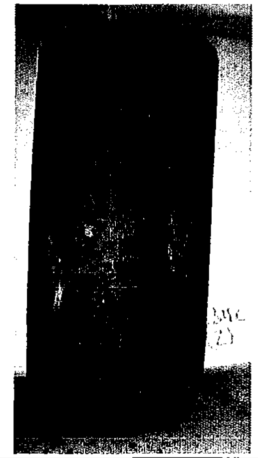
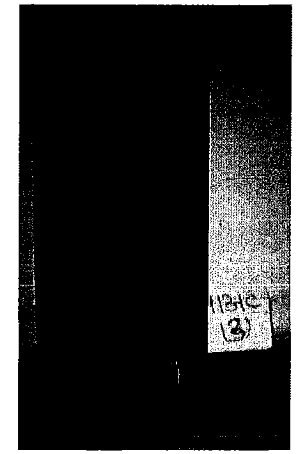
Série 1134C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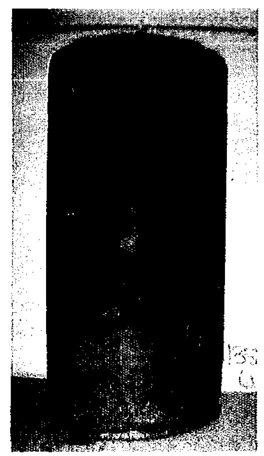	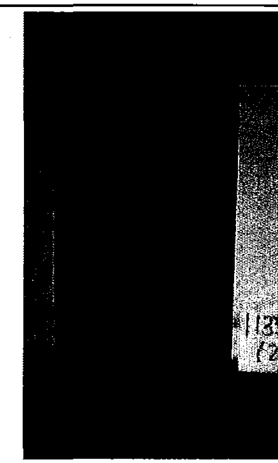
Échantillon 1	**Échantillon 2**

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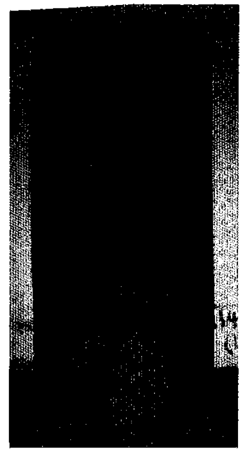
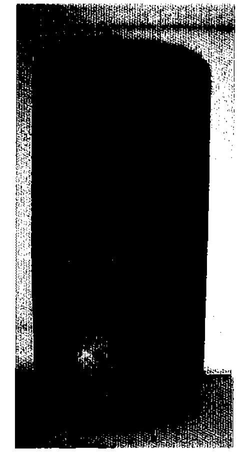
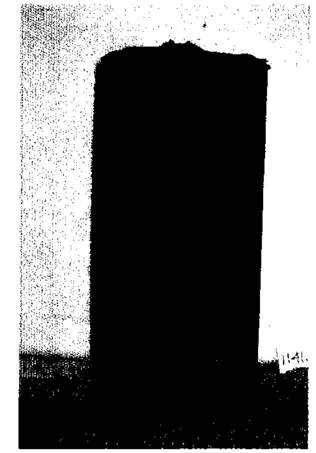
Annexe photo
F1417261-001

Série 1141C		
		
Échantillon 1	Échantillon 2	Échantillon 3

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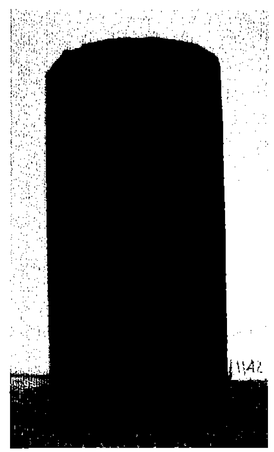	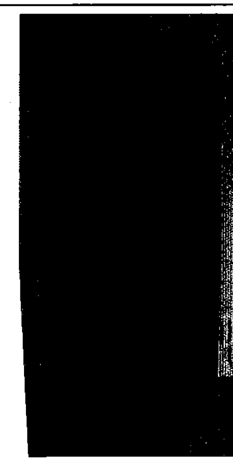	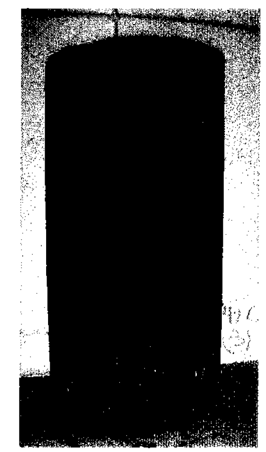
Échantillon 1	Échantillon 2	Échantillon 3

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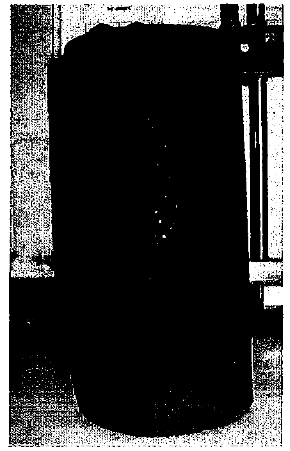	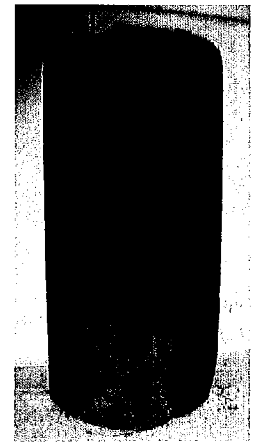	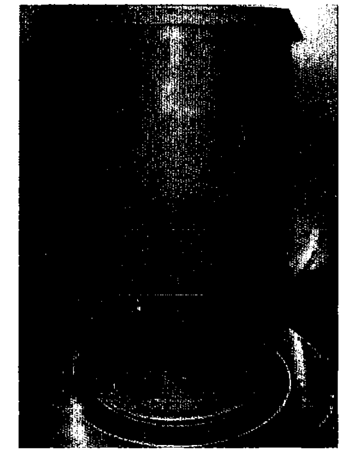
Échamtillon 1	Échantillon 2	Échantillon 3
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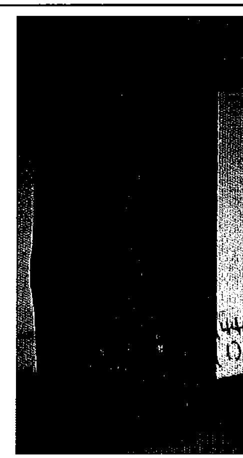
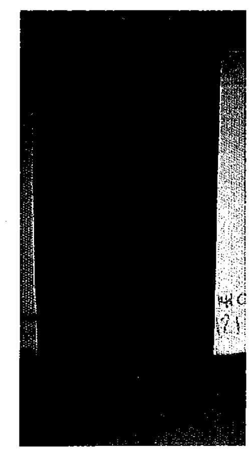
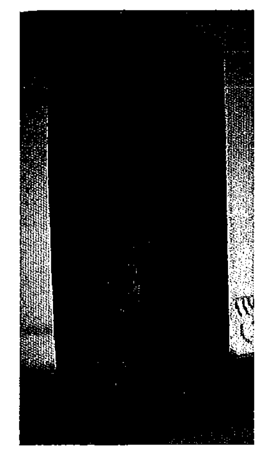
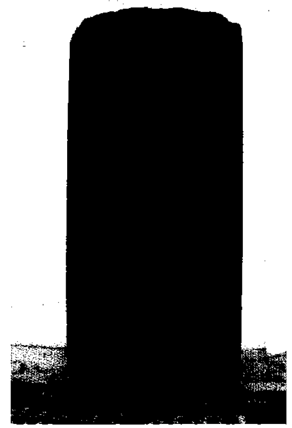
		
Échantillon 1	Échantillon 2	Échantillon 3

Série 1151C



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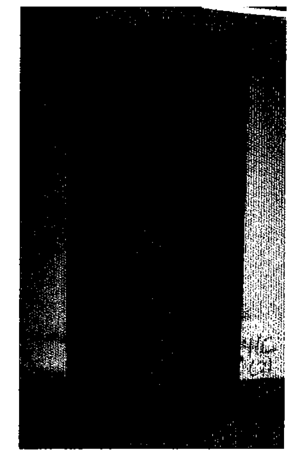

Échantillon 3

Série 1181C

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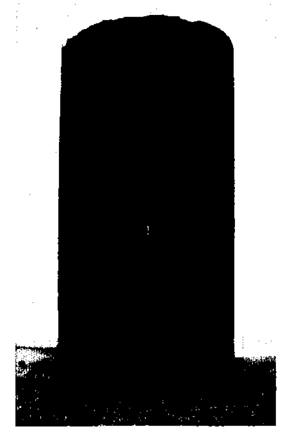

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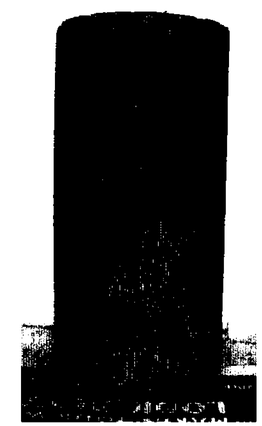
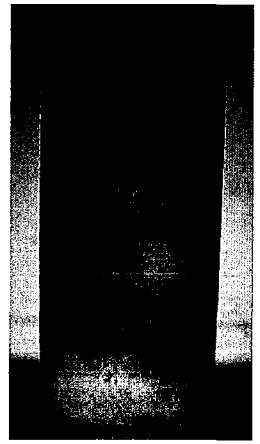


Échantillon 3

Série 1182C



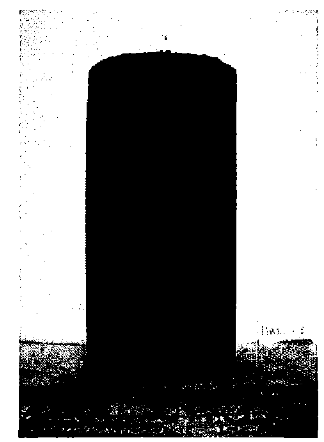
Échantillon 2

Échantillon 3

Série 1183C

Échantillon 1

Échantillon 2



Échantillon 3

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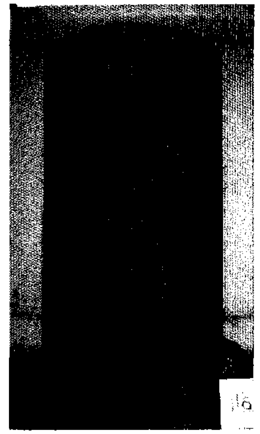	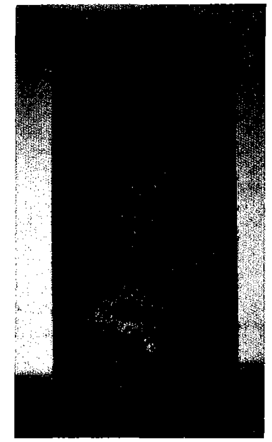	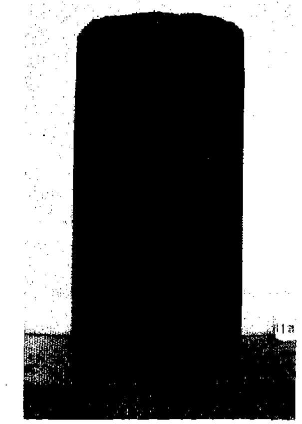
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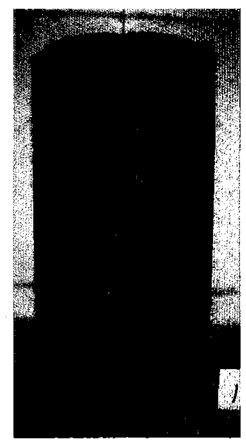	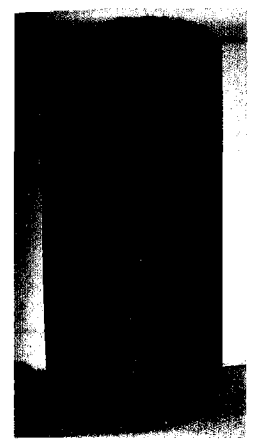	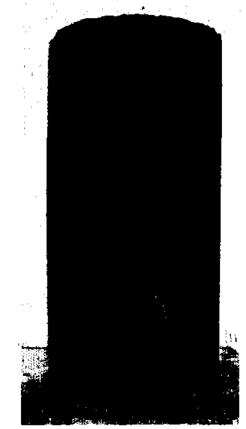
Échantillon 1	**Échantillon 2**	**Échantillon 3**

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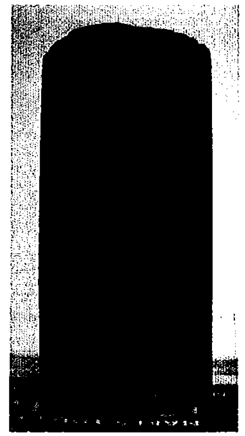	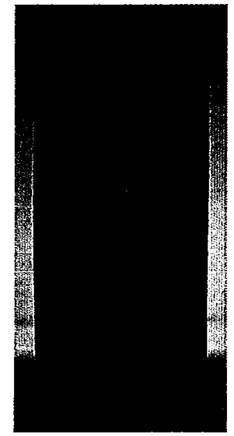	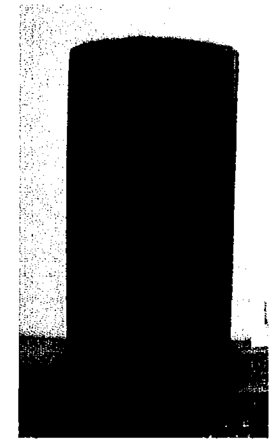
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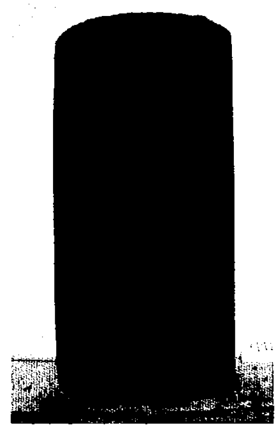	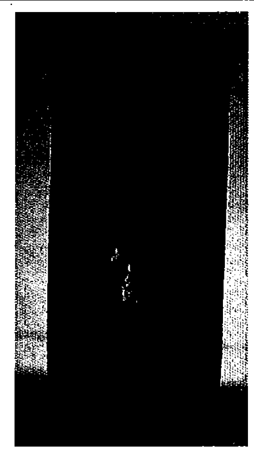	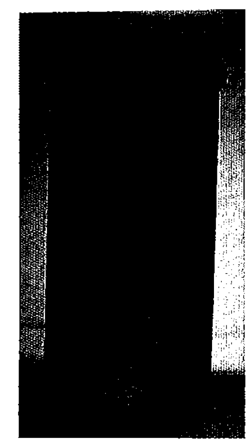
Échantillon 1	**Echantillon 2**	**Échantillon 3**

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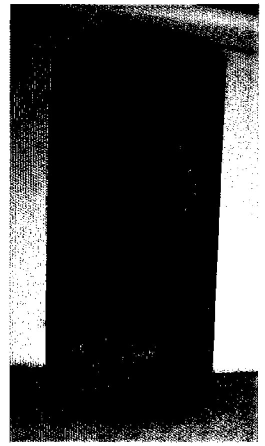	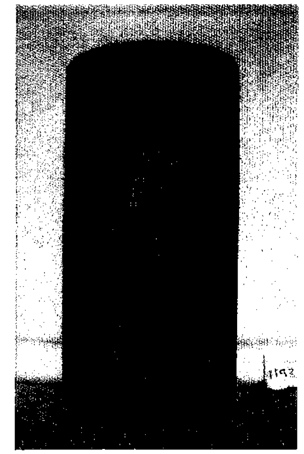	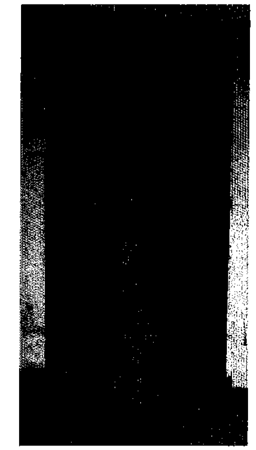
Échantillon 1	**Échantillon 2**	**Échantillon 3**
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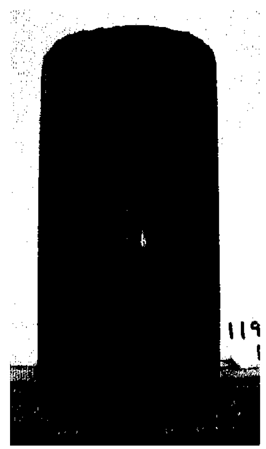	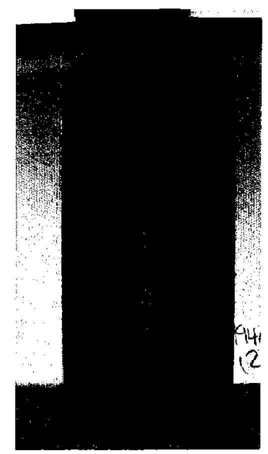	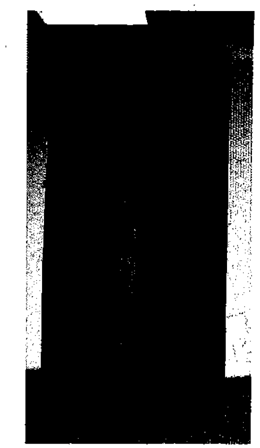
Échantillon 1	**Échantillon 2**	**Échantillon 3**

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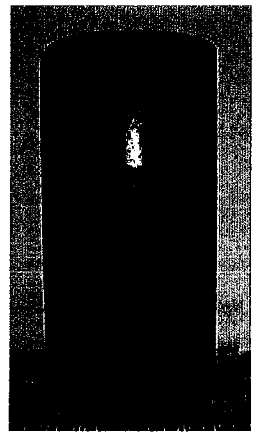	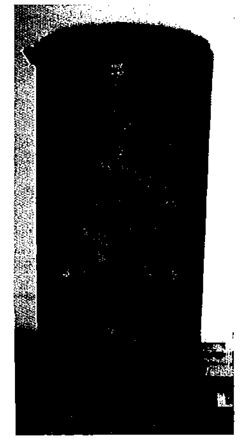	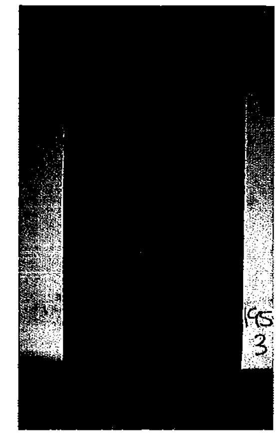
Échantillon 1	**Echantillon 2**	**Echantillon 3**
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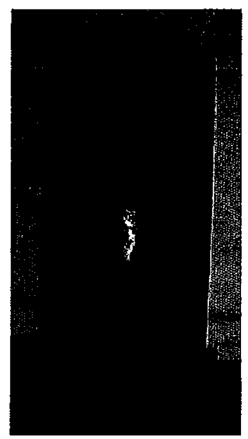	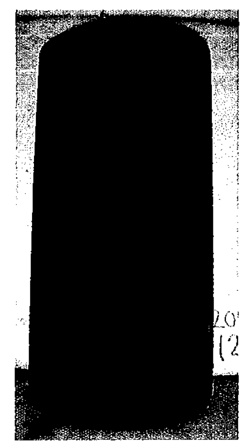	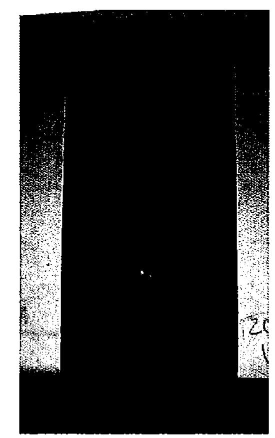
Échantillon 1	**Échantillon 2**	**Échantillon 3**

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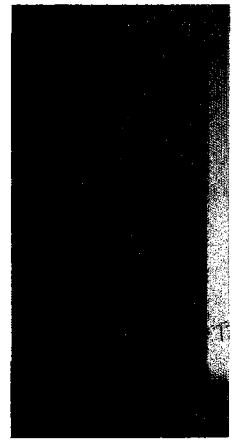	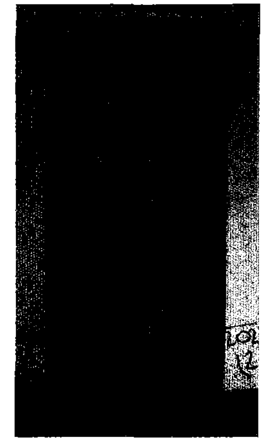	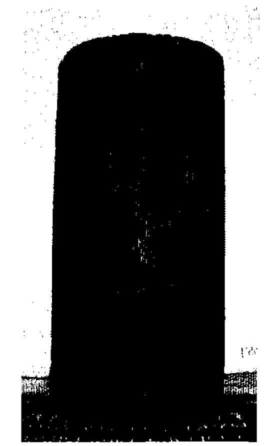
Échantillon 1	Échantillon 2	Échantillon 3
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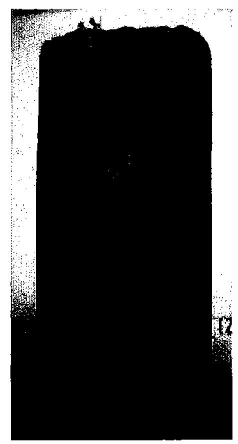	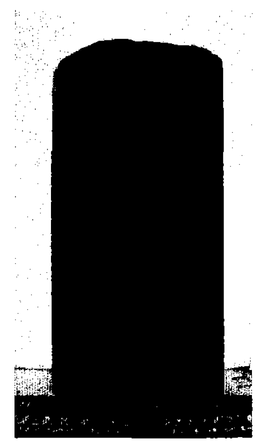	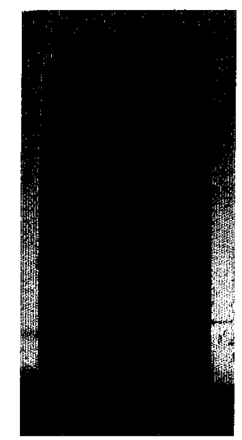
Échantillon 1	Échantillon 2	Échantillon 3

Série 1204C

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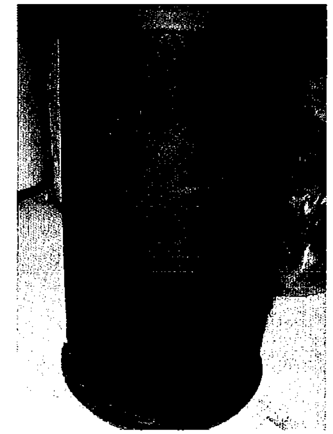
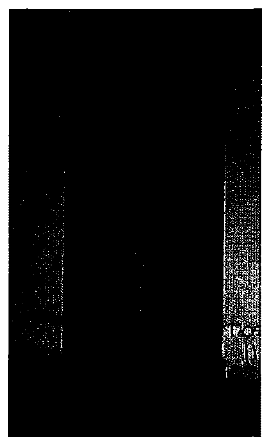
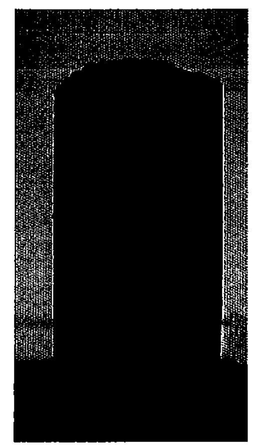


Échantillon 2

Série 1205C



Échantillon 1



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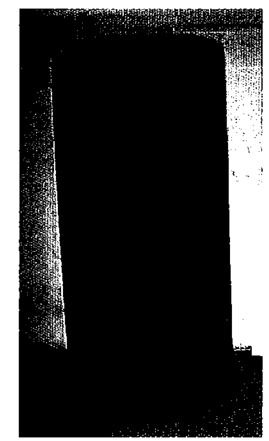

Échantillon 3

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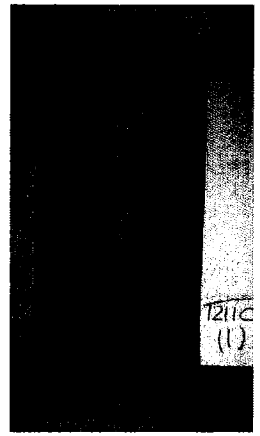	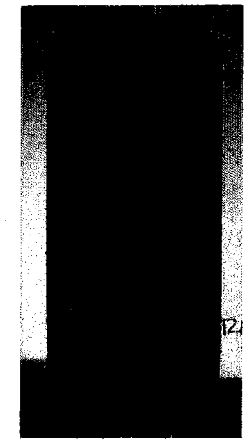	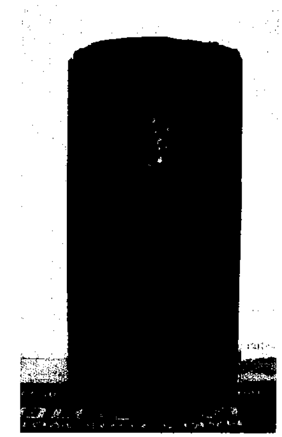
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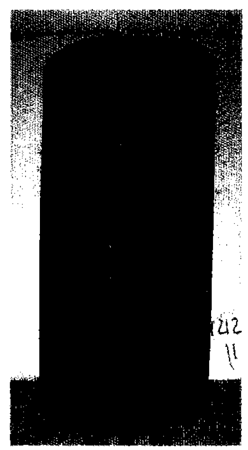	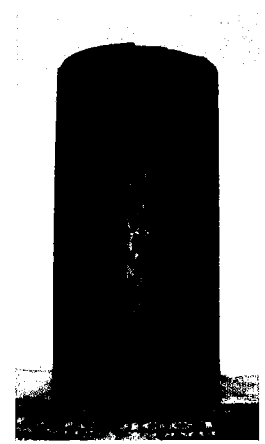	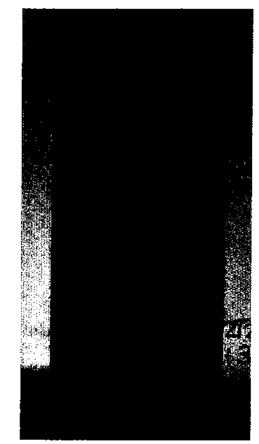
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	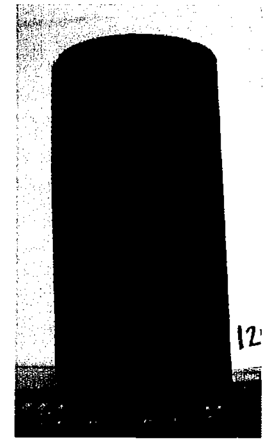	
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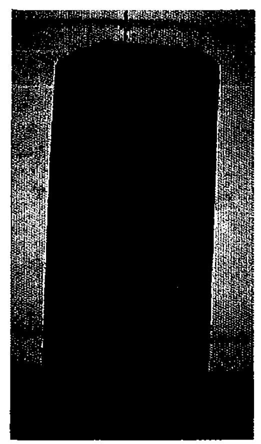	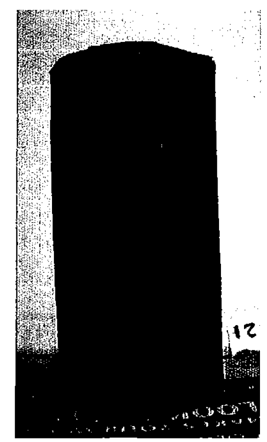	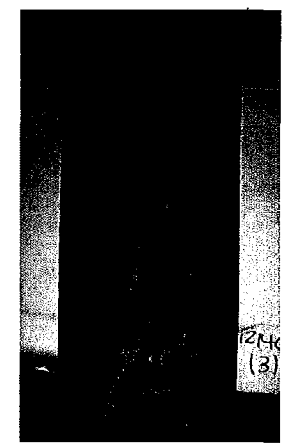
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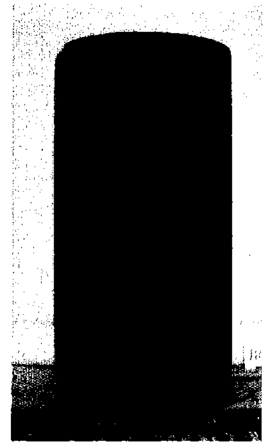	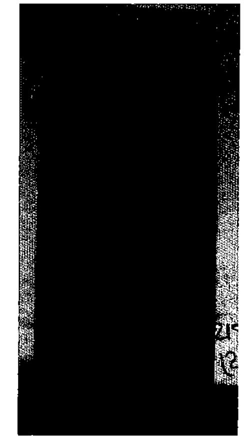
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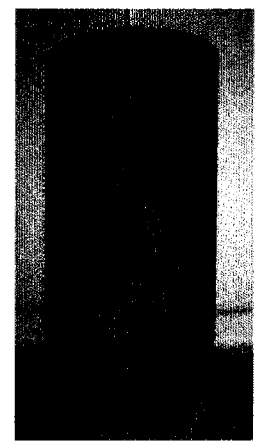
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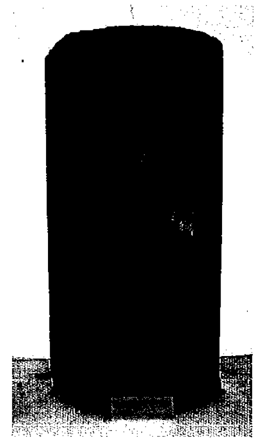	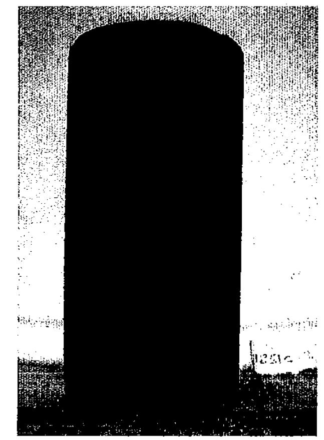
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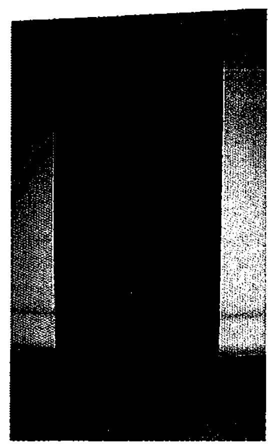	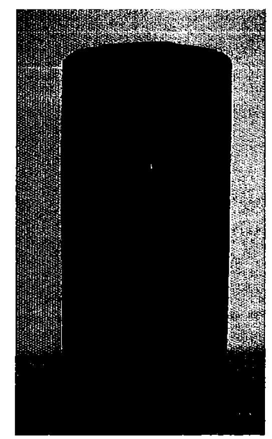	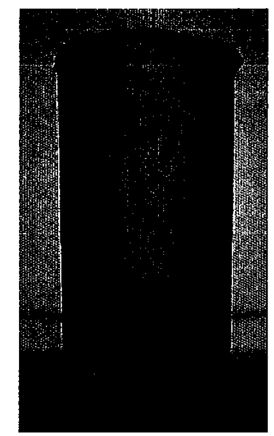
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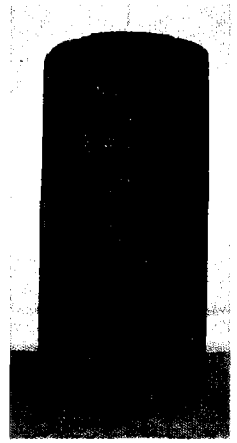
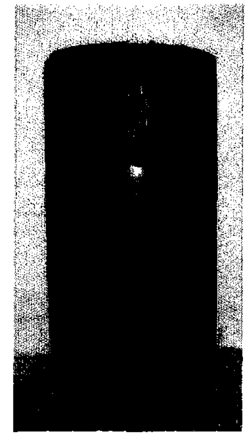
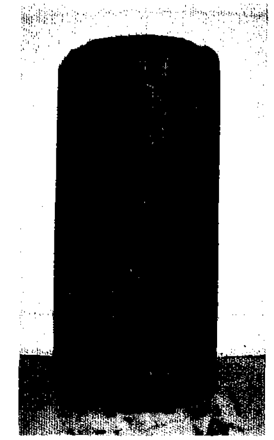
<tr><td></td><td></td><td></td></tr>
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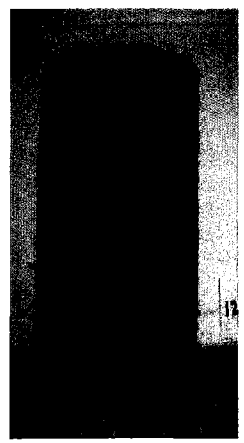
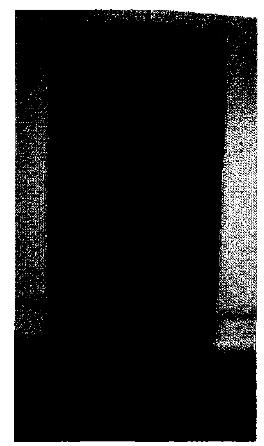
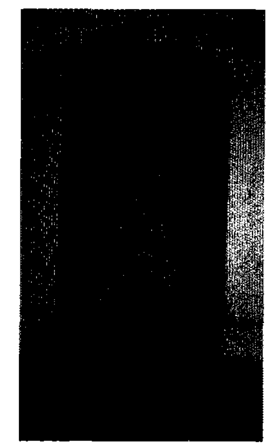
<tr><td></td><td></td><td></td></tr>
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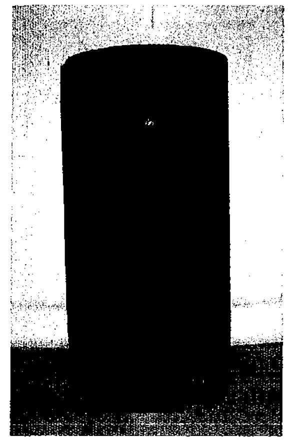
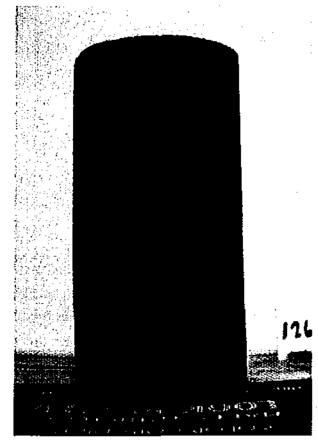
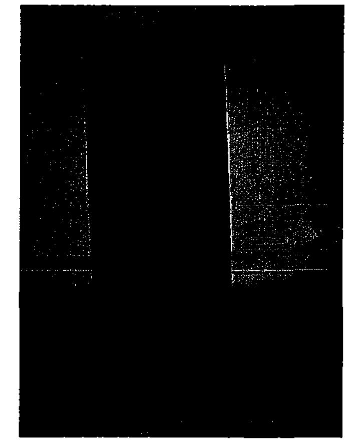
<tr><td></td><td>
</td><td></td></tr>
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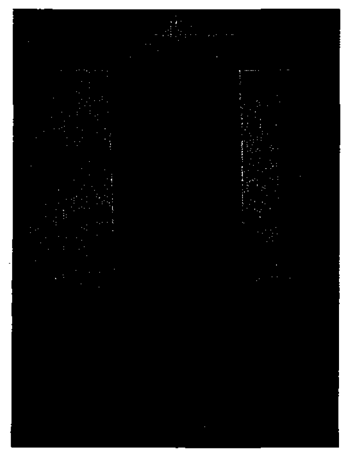
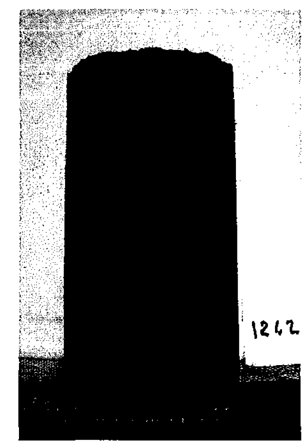
<tr><td></td><td>
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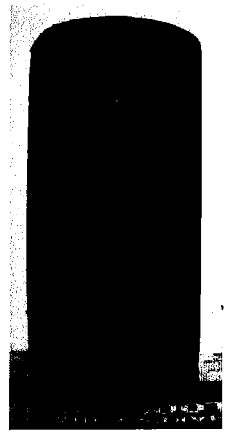	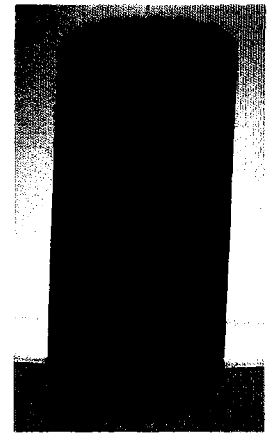	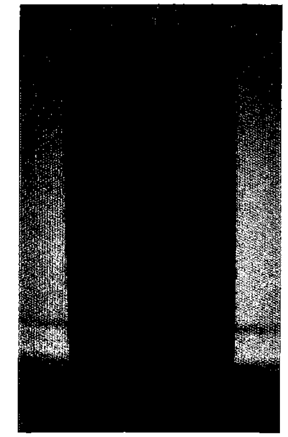
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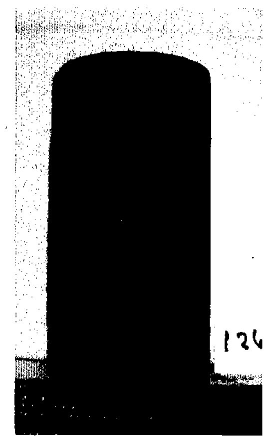	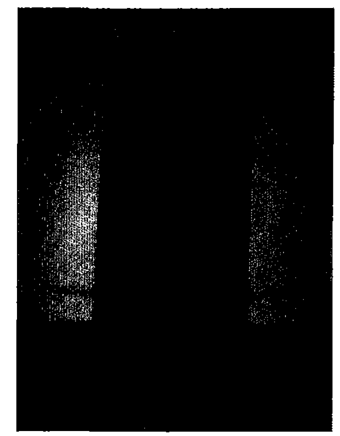
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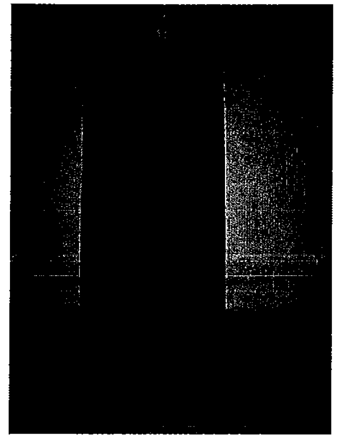	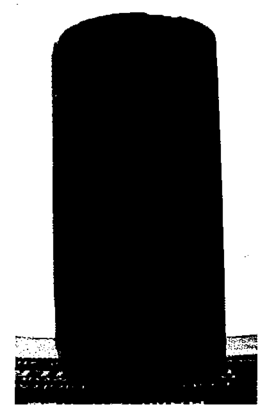	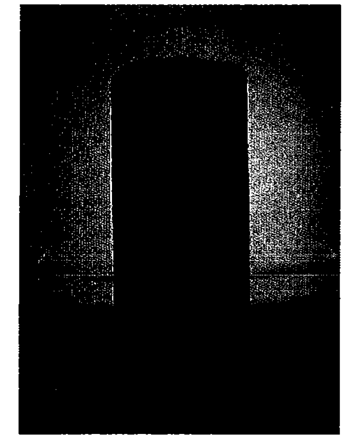
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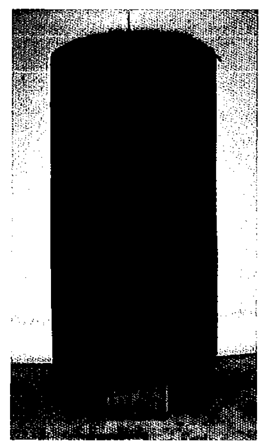	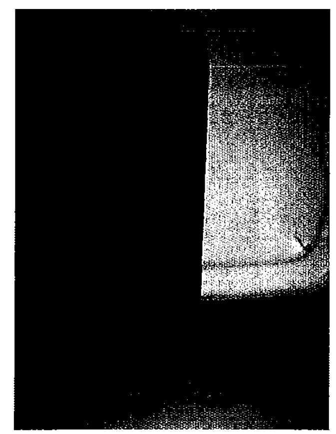	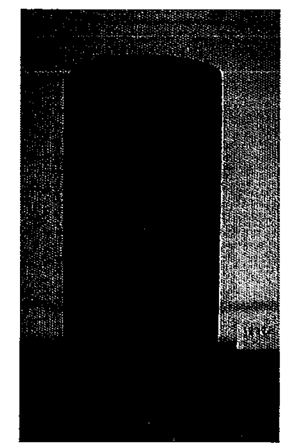
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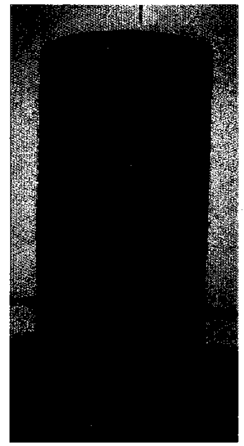	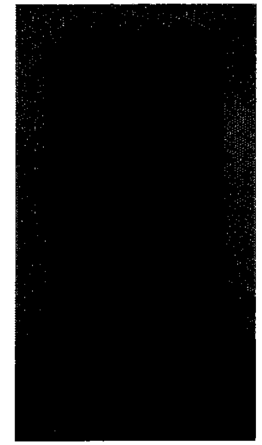	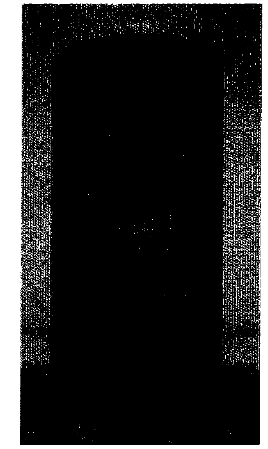
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	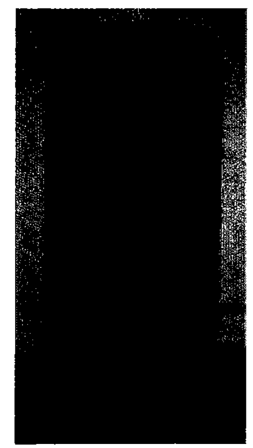	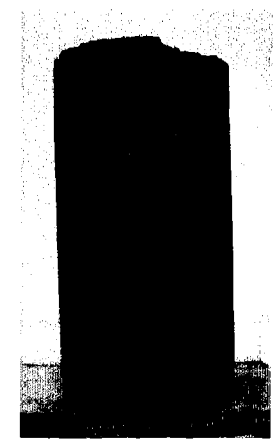
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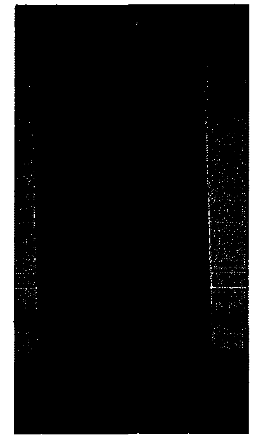

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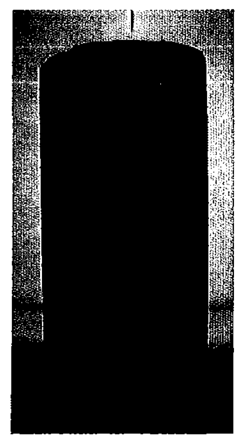

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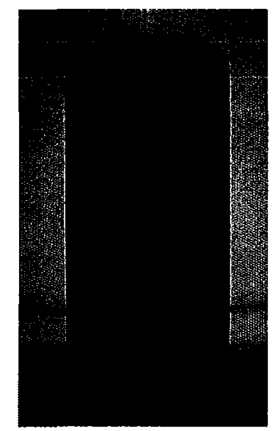

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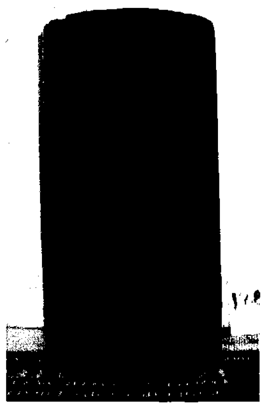	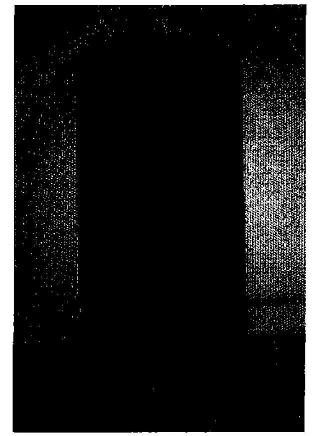
Échantillon 2	Échantillon 3

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ANNEXE 4

NORMES DE RÉFÉRENCES

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens[1]

This standard is issued under the fixed designation C39/C39M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method covers determination of compressive strength of cylindrical concrete specimens such as molded cylinders and drilled cores. It is limited to concrete having a density in excess of 800 kg/m^3 [50 lb/ft^3].

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The inch-pound units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* (**Warning**—Means should be provided to contain concrete fragments during sudden rupture of specimens. Tendency for sudden rupture increases with increasing concrete strength and it is more likely when the testing machine is relatively flexible. The safety precautions given in the Manual of Aggregate and Concrete Testing are recommended.)

1.4 The text of this standard references notes which provide explanatory material. These notes shall not be considered as requirements of the standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field
C42/C42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
C617 Practice for Capping Cylindrical Concrete Specimens
C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
C873 Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds
C1077 Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
C1231/C1231M Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders
E4 Practices for Force Verification of Testing Machines
E74 Practice of Calibration of Force-Measuring Instruments for Verifying the Force Indication of Testing Machines
Manual of Aggregate and Concrete Testing

3. Summary of Test Method

3.1 This test method consists of applying a compressive axial load to molded cylinders or cores at a rate which is within a prescribed range until failure occurs. The compressive strength of the specimen is calculated by dividing the maximum load attained during the test by the cross-sectional area of the specimen.

4. Significance and Use

4.1 Care must be exercised in the interpretation of the significance of compressive strength determinations by this test method since strength is not a fundamental or intrinsic property of concrete made from given materials. Values obtained will depend on the size and shape of the specimen, batching, mixing

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.61 on Testing for Strength.

Current edition approved Oct. 1, 2010. Published November 2010. Originally approved in 1921. Last previous edition approved in 2009 as C39/C39M–09a. DOI: 10.1520/C0039_C0039M-10.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard.

procedures, the methods of sampling, molding, and fabrication and the age, temperature, and moisture conditions during curing.

4.2 This test method is used to determine compressive strength of cylindrical specimens prepared and cured in accordance with Practices C31/C31M, C192/C192M, C617, and C1231/C1231M and Test Methods C42/C42M and C873.

4.3 The results of this test method are used as a basis for quality control of concrete proportioning, mixing, and placing operations; determination of compliance with specifications; control for evaluating effectiveness of admixtures; and similar uses.

4.4 The individual who tests concrete cylinders for acceptance testing shall meet the concrete laboratory technician requirements of Practice C1077, including an examination requiring performance demonstration that is evaluated by an independent examiner.

NOTE 1—Certification equivalent to the minimum guidelines for ACI Concrete Laboratory Technician, Level I or ACI Concrete Strength Testing Technician will satisfy this requirement.

5. Apparatus

5.1 *Testing Machine*—The testing machine shall be of a type having sufficient capacity and capable of providing the rates of loading prescribed in 7.5.

5.1.1 Verify calibration of the testing machines in accordance with Practices E4, except that the verified loading range shall be as required in 5.3. Verification is required under the following conditions:

5.1.1.1 At least annually, but not to exceed 13 months,

5.1.1.2 On original installation or immediately after relocation,

5.1.1.3 Immediately after making repairs or adjustments that affect the operation of the force applying system or the values displayed on the load indicating system, except for zero adjustments that compensate for the mass of bearing blocks or specimen, or both, or

5.1.1.4 Whenever there is reason to suspect the accuracy of the indicated loads.

5.1.2 *Design*—The design of the machine must include the following features:

5.1.2.1 The machine must be power operated and must apply the load continuously rather than intermittently, and without shock. If it has only one loading rate (meeting the requirements of 7.5), it must be provided with a supplemental means for loading at a rate suitable for verification. This supplemental means of loading may be power or hand operated.

5.1.2.2 The space provided for test specimens shall be large enough to accommodate, in a readable position, an elastic calibration device which is of sufficient capacity to cover the potential loading range of the testing machine and which complies with the requirements of Practice E74.

NOTE 2—The types of elastic calibration devices most generally available and most commonly used for this purpose are the circular proving ring or load cell.

5.1.3 *Accuracy*—The accuracy of the testing machine shall be in accordance with the following provisions:

5.1.3.1 The percentage of error for the loads within the proposed range of use of the testing machine shall not exceed ±1.0 % of the indicated load.

5.1.3.2 The accuracy of the testing machine shall be verified by applying five test loads in four approximately equal increments in ascending order. The difference between any two successive test loads shall not exceed one third of the difference between the maximum and minimum test loads.

5.1.3.3 The test load as indicated by the testing machine and the applied load computed from the readings of the verification device shall be recorded at each test point. Calculate the error, E, and the percentage of error, E_p, for each point from these data as follows:

$$E = A - B \quad (1)$$
$$E_p = 100(A - B)/B$$

where:

A = load, kN [lbf] indicated by the machine being verified, and

B = applied load, kN [lbf] as determined by the calibrating device.

5.1.3.4 The report on the verification of a testing machine shall state within what loading range it was found to conform to specification requirements rather than reporting a blanket acceptance or rejection. In no case shall the loading range be stated as including loads below the value which is 100 times the smallest change of load estimable on the load-indicating mechanism of the testing machine or loads within that portion of the range below 10 % of the maximum range capacity.

5.1.3.5 In no case shall the loading range be stated as including loads outside the range of loads applied during the verification test.

5.1.3.6 The indicated load of a testing machine shall not be corrected either by calculation or by the use of a calibration diagram to obtain values within the required permissible variation.

5.2 The testing machine shall be equipped with two steel bearing blocks with hardened faces (Note 3), one of which is a spherically seated block that will bear on the upper surface of the specimen, and the other a solid block on which the specimen shall rest. Bearing faces of the blocks shall have a minimum dimension at least 3 % greater than the diameter of the specimen to be tested. Except for the concentric circles described below, the bearing faces shall not depart from a plane by more than 0.02 mm [0.001 in.] in any 150 mm [6 in.] of blocks 150 mm [6 in.] in diameter or larger, or by more than 0.02 mm [0.001 in.] in the diameter of any smaller block; and new blocks shall be manufactured within one half of this tolerance. When the diameter of the bearing face of the spherically seated block exceeds the diameter of the specimen by more than 13 mm [0.5 in.], concentric circles not more than 0.8 mm [0.03 in.] deep and not more than 1 mm [0.04 in.] wide shall be inscribed to facilitate proper centering.

NOTE 3—It is desirable that the bearing faces of blocks used for compression testing of concrete have a Rockwell hardness of not less than 55 HRC.

5.2.1 Bottom bearing blocks shall conform to the following requirements:

5.2.1.1 The bottom bearing block is specified for the purpose of providing a readily machinable surface for maintenance of the specified surface conditions (Note 4). The top and bottom surfaces shall be parallel to each other. If the testing machine is so designed that the platen itself is readily maintained in the specified surface condition, a bottom block is not required. Its least horizontal dimension shall be at least 3 % greater than the diameter of the specimen to be tested. Concentric circles as described in 5.2 are optional on the bottom block.

NOTE 4—The block may be fastened to the platen of the testing machine.

5.2.1.2 Final centering must be made with reference to the upper spherical block. When the lower bearing block is used to assist in centering the specimen, the center of the concentric rings, when provided, or the center of the block itself must be directly below the center of the spherical head. Provision shall be made on the platen of the machine to assure such a position.

5.2.1.3 The bottom bearing block shall be at least 25 mm [1 in.] thick when new, and at least 22.5 mm [0.9 in.] thick after any resurfacing operations.

5.2.2 The spherically seated bearing block shall conform to the following requirements:

5.2.2.1 The maximum diameter of the bearing face of the suspended spherically seated block shall not exceed the values given below:

Diameter of Test Specimens, mm [in.]	Maximum Diameter of Bearing Face, mm [in.]
50 [2]	105 [4]
75 [3]	130 [5]
100 [4]	165 [6.5]
150 [6]	255 [10]
200 [8]	280 [11]

NOTE 5—Square bearing faces are permissible, provided the diameter of the largest possible inscribed circle does not exceed the above diameter.

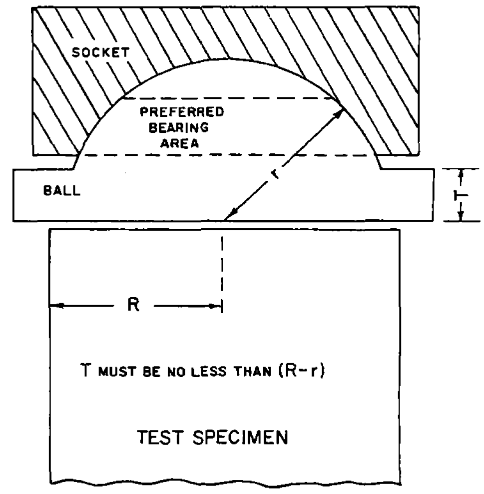
5.2.2.2 The center of the sphere shall coincide with the surface of the bearing face within a tolerance of ±5 % of the radius of the sphere. The diameter of the sphere shall be at least 75 % of the diameter of the specimen to be tested.

5.2.2.3 The ball and the socket shall be designed so that the steel in the contact area does not permanently deform when loaded to the capacity of the testing machine.

NOTE 6—The preferred contact area is in the form of a ring (described as "preferred bearing area") as shown on Fig. 1.

5.2.2.4 The curved surfaces of the socket and of the spherical portion shall be kept clean and shall be lubricated with a petroleum-type oil such as conventional motor oil, not with a pressure type grease. After contacting the specimen and application of small initial load, further tilting of the spherically seated block is not intended and is undesirable.

5.2.2.5 If the radius of the sphere is smaller than the radius of the largest specimen to be tested, the portion of the bearing face extending beyond the sphere shall have a thickness not less than the difference between the radius of the sphere and radius of the specimen. The least dimension of the bearing face shall be at least as great as the diameter of the sphere (see Fig. 1).



NOTE—Provision shall be made for holding the ball in the socket and for holding the entire unit in the testing machine.

FIG. 1 Schematic Sketch of a Typical Spherical Bearing Block

5.2.2.6 The movable portion of the bearing block shall be held closely in the spherical seat, but the design shall be such that the bearing face can be rotated freely and tilted at least 4° in any direction.

5.2.2.7 If the ball portion of the upper bearing block is a two-piece design composed of a spherical portion and a bearing plate, a mechanical means shall be provided to ensure that the spherical portion is fixed and centered on the bearing plate.

5.3 *Load Indication:*

5.3.1 If the load of a compression machine used in concrete testing is registered on a dial, the dial shall be provided with a graduated scale that is readable to at least the nearest 0.1 % of the full scale load (Note 7). The dial shall be readable within 1 % of the indicated load at any given load level within the loading range. In no case shall the loading range of a dial be considered to include loads below the value that is 100 times the smallest change of load that can be read on the scale. The scale shall be provided with a graduation line equal to zero and so numbered. The dial pointer shall be of sufficient length to reach the graduation marks; the width of the end of the pointer shall not exceed the clear distance between the smallest graduations. Each dial shall be equipped with a zero adjustment located outside the dialcase and easily accessible from the front of the machine while observing the zero mark and dial pointer. Each dial shall be equipped with a suitable device that at all times, until reset, will indicate to within 1 % accuracy the maximum load applied to the specimen.

NOTE 7—Readability is considered to be 0.5 mm [0.02 in.] along the arc described by the end of the pointer. Also, one half of a scale interval is readable with reasonable certainty when the spacing on the load indicating mechanism is between 1 mm [0.04 in.] and 2 mm [0.06 in.]. When the spacing is between 2 and 3 mm [0.06 and 0.12 in.], one third of a scale interval is readable with reasonable certainty. When the spacing is 3 mm [0.12 in.] or more, one fourth of a scale interval is readable with reasonable certainty.

5.3.2 If the testing machine load is indicated in digital form, the numerical display must be large enough to be easily read.

The numerical increment must be equal to or less than 0.10 % of the full scale load of a given loading range. In no case shall the verified loading range include loads less than the minimum numerical increment multiplied by 100. The accuracy of the indicated load must be within 1.0 % for any value displayed within the verified loading range. Provision must be made for adjusting to indicate true zero at zero load. There shall be provided a maximum load indicator that at all times until reset will indicate within 1 % system accuracy the maximum load applied to the specimen.

6. Specimens

6.1 Specimens shall not be tested if any individual diameter of a cylinder differs from any other diameter of the same cylinder by more than 2 %.

NOTE 8—This may occur when single use molds are damaged or deformed during shipment, when flexible single use molds are deformed during molding, or when a core drill deflects or shifts during drilling.

6.2 Prior to testing, neither end of test specimens shall depart from perpendicularity to the axis by more than 0.5° (approximately equivalent to 1 mm in 100 mm [0.12 in. in 12 in.]). The ends of compression test specimens that are not plane within 0.050 mm [0.002 in.] shall be sawed or ground to meet that tolerance, or capped in accordance with either Practice C617 or, when permitted, Practice C1231/C1231M. The diameter used for calculating the cross-sectional area of the test specimen shall be determined to the nearest 0.25 mm [0.01 in.] by averaging two diameters measured at right angles to each other at about midheight of the specimen.

6.3 The number of individual cylinders measured for determination of average diameter is not prohibited from being reduced to one for each ten specimens or three specimens per day, whichever is greater, if all cylinders are known to have been made from a single lot of reusable or single-use molds which consistently produce specimens with average diameters within a range of 0.5 mm [0.02 in.]. When the average diameters do not fall within the range of 0.5 mm [0.02 in.] or when the cylinders are not made from a single lot of molds, each cylinder tested must be measured and the value used in calculation of the unit compressive strength of that specimen. When the diameters are measured at the reduced frequency, the cross-sectional areas of all cylinders tested on that day shall be computed from the average of the diameters of the three or more cylinders representing the group tested that day.

6.4 If the purchaser of the testing services requests measurement of density of test specimens, determine the mass of specimens before capping. Remove any surface moisture with a towel and measure the mass of the specimen using a balance or scale that is accurate to within 0.3 % of the mass being measured. Measure the length of the specimen to the nearest 1 mm [0.05 in.] at three locations spaced evenly around the circumference. Compute the average length and record to the nearest 1 mm [0.05 in.]. Alternatively, determine the cylinder density by weighing the cylinder in air and then submerged under water at 23.0 ± 2.0 °C [73.5 ± 3.5 °F], and computing the volume according to 8.3.1.

6.5 When density determination is not required and the length to diameter ratio is less than 1.8 or more than 2.2, measure the length of the specimen to the nearest 0.05 D.

7. Procedure

7.1 Compression tests of moist-cured specimens shall be made as soon as practicable after removal from moist storage.

7.2 Test specimens shall be kept moist by any convenient method during the period between removal from moist storage and testing. They shall be tested in the moist condition.

7.3 All test specimens for a given test age shall be broken within the permissible time tolerances prescribed as follows:

Test Age	Permissible Tolerance
24 h	± 0.5 h or 2.1 %
3 days	2 h or 2.8 %
7 days	6 h or 3.6 %
28 days	20 h or 3.0 %
90 days	2 days 2.2 %

7.4 *Placing the Specimen*—Place the plain (lower) bearing block, with its hardened face up, on the table or platen of the testing machine directly under the spherically seated (upper) bearing block. Wipe clean the bearing faces of the upper and lower bearing blocks and of the test specimen and place the test specimen on the lower bearing block. Carefully align the axis of the specimen with the center of thrust of the spherically seated block.

7.4.1 *Zero Verification and Block Seating*—Prior to testing the specimen, verify that the load indicator is set to zero. In cases where the indicator is not properly set to zero, adjust the indicator (Note 9). After placing the specimen in the machine but prior to applying the load on the specimen, tilt the movable portion of the spherically seated block gently by hand so that the bearing face appears to be parallel to the top of the test specimen.

NOTE 9—The technique used to verify and adjust load indicator to zero will vary depending on the machine manufacturer. Consult your owner's manual or compression machine calibrator for the proper technique.

7.5 *Rate of Loading*—Apply the load continuously and without shock.

7.5.1 The load shall be applied at a rate of movement (platen to crosshead measurement) corresponding to a stress rate on the specimen of 0.25 ± 0.05 MPa/s [35 ± 7 psi/s] (See Note 10). The designated rate of movement shall be maintained at least during the latter half of the anticipated loading phase.

NOTE 10—For a screw-driven or displacement-controlled testing machine, preliminary testing will be necessary to establish the required rate of movement to achieve the specified stress rate. The required rate of movement will depend on the size of the test specimen, the elastic modulus of the concrete, and the stiffness of the testing machine.

7.5.2 During application of the first half of the anticipated loading phase, a higher rate of loading shall be permitted. The higher loading rate shall be applied in a controlled manner so that the specimen is not subjected to shock loading.

7.5.3 Make no adjustment in the rate of movement (platen to crosshead) as the ultimate load is being approached and the stress rate decreases due to cracking in the specimen.

7.6 Apply the compressive load until the load indicator shows that the load is decreasing steadily and the specimen displays a well-defined fracture pattern (Types 1 to 4 in Fig. 2). For a testing machine equipped with a specimen break detector, automatic shut-off of the testing machine is prohibited until the load has dropped to a value that is less than 95 % of the peak load. When testing with unbonded caps, a corner fracture similar to a Type 5 or 6 pattern shown in Fig. 2 may occur before the ultimate capacity of the specimen has been attained. Continue compressing the specimen until the user is certain that the ultimate capacity has been attained. Record the maximum load carried by the specimen during the test, and note the type of fracture pattern according to Fig. 2. If the fracture pattern is not one of the typical patterns shown in Fig. 2, sketch and describe briefly the fracture pattern. If the measured strength is lower than expected, examine the fractured concrete and note the presence of large air voids, evidence of segregation, whether fractures pass predominantly around or through the coarse aggregate particles, and verify end preparations were in accordance with Practice C617 or Practice C1231/C1231M.

8. Calculation

8.1 Calculate the compressive strength of the specimen by dividing the maximum load carried by the specimen during the test by the average cross-sectional area determined as described in Section 6 and express the result to the nearest 0.1 MPa [10 psi].

8.2 If the specimen length to diameter ratio is 1.75 or less, correct the result obtained in 8.1 by multiplying by the appropriate correction factor shown in the following table Note 11:

L/D:	1.75	1.50	1.25	1.00
Factor:	0.98	0.96	0.93	0.87

Use interpolation to determine correction factors for L/D values between those given in the table.

NOTE 11—Correction factors depend on various conditions such as moisture condition, strength level, and elastic modulus. Average values are given in the table. These correction factors apply to low-density concrete weighing between 1600 and 1920 kg/m^3 [100 and 120 lb/ft^3] and to normal-density concrete. They are applicable to concrete dry or soaked at the time of loading and for nominal concrete strengths from 14 to 42 MPa [2000 to 6000 psi]. For strengths higher than 42 MPai [6000 ps] correction factors may be larger than the values listed above[3].

[3] Bartlett, F.M. and MacGregor, J.G., "Effect of Core Length-to-Diameter Ratio on Concrete Core Strength," *ACI Materials Journal*, Vol 91, No. 4, July-August, 1994 , pp. 339-348.

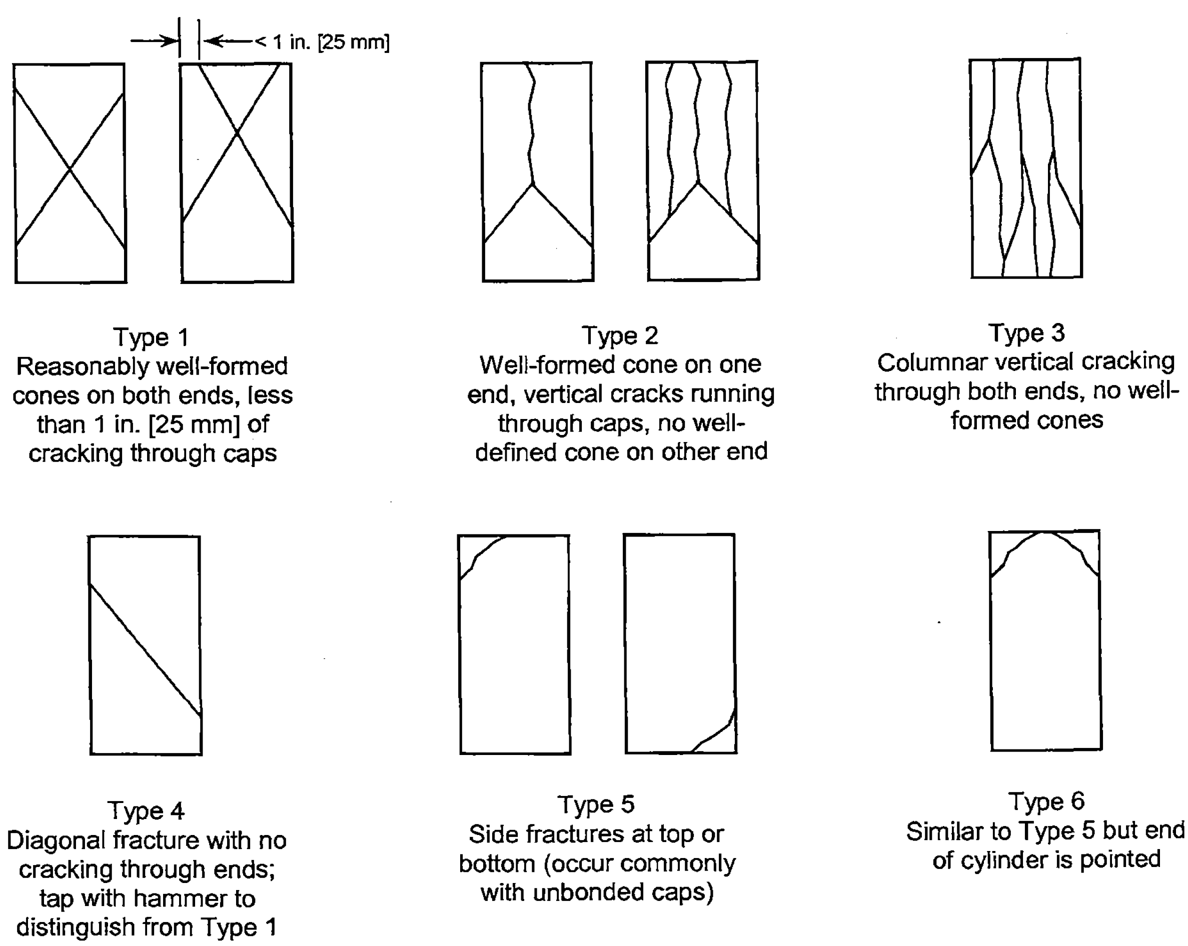


FIG. 2 Schematic of Typical Fracture Patterns

8.3 When required, calculate the density of the specimen to the nearest 10 kg/m³ [1 lb/ft³] as follows:

$$Density = \frac{W}{V} \quad (2)$$

where:
W = mass of specimen, kg [lb], and
V = volume of specimen computed from the average diameter and average length or from weighing the cylinder in air and submerged, m^3 [ft^3]

8.3.1 When the volume is determined from submerged weighing, calculate the volume as follows:

$$V = \frac{W - W_s}{\gamma_w} \quad (3)$$

where:
W_s = apparent mass of submerged specimen, kg [lb], and
γ_w = density of water at 23 °C [73.5 °F] = 997.5 kg/m^3 [62.27 lbs/ft^3].

9. Report

9.1 Report the following information:

9.1.1 Identification number,

9.1.2 Average measured diameter (and measured length, if outside the range of 1.8 *D* to 2.2 *D*), in millimetres [inches],

9.1.3 Cross-sectional area, in square millimetres [square inches],

9.1.4 Maximum load, in kilonewtons [pounds-force],

9.1.5 Compressive strength calculated to the nearest 0.1 MPa [10 psi],

9.1.6 Type of fracture, if other than the usual cone (see Fig. 2),

9.1.7 Defects in either specimen or caps, and,

9.1.8 Age of specimen.

9.1.9 When determined, the density to the nearest 10 kg/m^3 [1 lb/ft^3].

10. Precision and Bias

10.1 *Precision*

10.1.1 *Within-Test Precision*—The following table provides the within-test precision of tests of 150 by 300 mm [6 by 12 in.] and 100 by 200 mm [4 by 8 in.] cylinders made from a well-mixed sample of concrete under laboratory conditions and under field conditions (see 10.1.2).

	Coefficient of Variation[4]	Acceptable Range[4] of Individual Cylinder Strengths	
		2 cylinders	3 cylinders
150 by 300 mm [6 by 12 in.]			
Laboratory conditions	2.4 %	6.6 %	7.8 %
Field conditions	2.9 %	8.0 %	9.5 %
100 by 200 mm [4 by 8 in.]			
Laboratory conditions	3.2 %	9.0 %	10.6 %

10.1.2 The within-test coefficient of variation represents the expected variation of measured strength of companion cylinders prepared from the same sample of concrete and tested by one laboratory at the same age. The values given for the within-test coefficient of variation of 150 by 300 mm [6 by 12 in.] cylinders are applicable for compressive strengths between 2000 and 15 to 55 MPa [8000 psi] and those for 100 by 200 mm [4 by 8 in.] cylinders are applicable for compressive strengths between 17 to 32 MPa [2500 and 4700 psi]. The within-test coefficients of variation for 150 by 300 mm [6 by 12 in.] cylinders are derived from CCRL concrete proficiency sample data for laboratory conditions and a collection of 1265 test reports from 225 commercial testing laboratories in 1978.[5] The within-test coefficient of variation of 100 by 200 mm [4 by 8 in.] cylinders are derived from CCRL concrete proficiency sample data for laboratory conditions.

10.1.3 *Multilaboratory Precision*—The multi-laboratory coefficient of variation for compressive strength test results of 150 by 300 mm [6 by 12 in.] cylinders has been found to be 5.0 %[4]; therefore, the results of properly conducted tests by two laboratories on specimens prepared from the same sample of concrete are not expected to differ by more than 14 %[4] of the average (See Note 12). A strength test result is the average of two cylinders tested at the same age.

NOTE 12—The multilaboratory precision does not include variations associated with different operators preparing test specimens from split or independent samples of concrete. These variations are expected to increase the multilaboratory coefficient of variation.

10.1.4 The multilaboratory data were obtained from six separate organized strength testing round robin programs where 150 x 300 mm [6 x 12 in.] cylindrical specimens were prepared at a single location and tested by different laboratories. The range of average strength from these programs was 17.0 to 90 MPa [2500 to 13 000 psi].

NOTE 13—Subcommittee C09.61 will continue to examine recent concrete proficiency sample data and field test data and make revisions to precisions statements when data indicate that they can be extended to cover a wider range of strengths and specimen sizes.

10.2 *Bias*—Since there is no accepted reference material, no statement on bias is being made.

[4] These numbers represent respectively the (1s %) and (d2s %) limits as described in Practice C670.

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1006.

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this test method since the last issue, C39/C39M–09a, that may impact the use of this test method. (Approved October 1, 2010)

(*1*) Revised 7.4.1 to remove the requirement for adjustment of the spherically seated block while the machine is moving and to clarify the objective of the manual adjustment before testing.

(*2*) Revised 9.1.2 to clarify that it is the average measured diameter (and measured length if applicable) that is to be reported.

Committee C09 has identified the location of selected changes to this test method since the last issue, C39/C39M–09, that may impact the use of this test method. (Approved December 15, 2009)

(*1*) Revised 1.1 to replace the term "unit weight" with the preferred term "density."

Committee C09 has identified the location of selected changes to this test method since the last issue, C39/C39M–05$^{\epsilon 2}$, that may impact the use of this test method. (Approved November 1, 2009)

(*1*) Revised Note 6 to clarify the reference to Fig. 1.

Designation: D 1633 – 00 (Reapproved 2007)

Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders[1]

This standard is issued under the fixed designation D 1633; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method covers the determination of the compressive strength of soil-cement using molded cylinders as test specimens.

1.2 Two alternative procedures are provided as follows:

1.2.1 *Method A*—This procedure uses a test specimen 4.0 in. (101.6 mm) in diameter and 4.584 in. (116.4 mm) in height. Height to diameter ratio equals 1.15. This test method made be used only on materials with 30 % or less retained on the ¾-in. (19.0-mm) sieve. See Note 3.

1.2.2 *Method B*—This procedure uses a test specimen 2.8 in. (71.1 mm) in diameter and 5.6 in. (142.2 mm) in height. Height to diameter ratio equals 2.00. This test method is applicable to those materials that pass the No. 4 (4.75-mm) sieve.

1.3 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026.

1.4 The values stated in inch-pound units are to be regarded as standard, except as noted in 1.4.1-1.4.3. The values given in parentheses are mathematical conversions to SI units, and are provided for information only and are not considered standard.

1.4.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.4.2 The slug unit of mass is almost never used in commercial practice (density, scales, balances, etc.). Therefore, the standard unit for mass in this standard is either kilogram (kg) or gram (g), or both. Also, the equivalent inch-pound unit (slug) is not given.

1.4.3 It is common practice in the engineering/construction profession in the United States to use concurrently pounds to represent both a unit of mass (lbm) and of force (lbf). This use combines two separate system of units, the absolute system and the gravitational system. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. As stated in 1.4.2, this standard uses the gravitational system and does not present the slug unit for mass. However, the use of scales or balances recording pounds of mass (lbm) or the recording of density in lbm/ft^3 shall not be regarded as nonconformance with this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 42/C 42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

D 559 Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures

D 560 Test Methods for Freezing and Thawing Compacted Soil-Cement Mixtures

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 1632 Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

D 6026 Practice for Using Significant Digits in Geotechnical Data

E 4 Practices for Force Verification of Testing Machines

3. Terminology

3.1 For definitions of terms used in this test method, refer to Terminology D 653.

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[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization With Admixtures.

Current edition approved Feb. 1, 2007. Published March 2007. Originally approved in 1959. Last previous edition approved in 2000 as D 1633 – 00.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

4. Significance and Use

4.1 Method A makes use of the same compaction equipment and molds commonly available in soil laboratories and used for other soil-cement tests. It is considered that Method A gives a relative measure of strength rather than a rigorous determination of compressive strength. Because of the lesser height to diameter ratio (1.15) of the cylinders, the compressive strength determined by Method A will normally be greater than that for Method B.

4.2 Method B, because of the greater height to diameter ratio (2.00), gives a better measure of compressive strength from a technical viewpoint since it reduces complex stress conditions that may occur during the shearing of Method A specimens.

4.3 In practice, Method A has been more commonly used than Method B. As a result, it has been customary to evaluate or specify compressive strength values as determined by Method A. A factor for converting compressive strength values based on height to diameter ratio is given in Section 8.[3]

NOTE 1—The agency performing this test method can be evaluated in accordance with Practice D 3740. Not withstanding statements on precision and bias contained in this test method: the precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not, in itself, ensure reliable testing. Reliable testing depends on many factors; Practice D 3740 provides a means of evaluating some of these factors.

5. Apparatus

5.1 *Compression Testing Machine*—This machine may be of any type having sufficient capacity and control to provide the rate of loading prescribed in 7.2. It shall conform to the requirements of Section 15 of Practices E 4. The testing machine shall be equipped with two steel bearing blocks with hardened faces (Note 2), one of which is a spherically seated head block that normally will bear on the upper surface of the specimen, and the other a plain rigid block on which the specimen will rest. The bearing faces shall be at least as large, and preferably slightly larger, than the surface of the specimen to which the load is applied. The bearing faces, when new, shall not depart from a plane by more than 0.0005 in. (0.013 mm) at any point, and they shall be maintained within a permissible variation limit of 0.001 in. (0.02 mm). In the spherically seated block, the diameter of the sphere shall not greatly exceed the diameter of the specimen and the center of the sphere shall coincide with the center of the bearing face. The movable portion of this block shall be held closely in the spherical seat, but the design shall be such that the bearing face can be rotated freely and tilted through small angles in any direction.

NOTE 2—It is desirable that the bearing faces of blocks used for compression testing of soil-cement have a hardness of not less than 60 HRC.

5.2 *Molds and Compaction Equipment*, in accordance with Test Methods D 559 or D 560 for Method A; Practice D 1632 for Method B.

6. Test Specimens

6.1 Mold the test specimens as follows:

6.1.1 *Method A*—Specimens are 4.0 in. (101.6 mm) in diameter and 4.584 in. (116.4 mm) in height and are molded in accordance with Test Methods D 559 or D 560.

6.1.2 *Method B*—Specimens are 2.8 in. (71.1 mm) in diameter and 5.6 in. (142.2 mm) in height and are molded in accordance with Practice D 1632.

NOTE 3—These methods may be used for testing specimens of other sizes. If the soil sample includes material retained on the 4.75-mm (No. 4) sieve, it is recommended that Method A be used, or that larger test specimens, 4.0 in. (101.6 mm) in diameter and 8.0 in. (203.2 mm) in height, be molded in a manner similar to Method B.

6.2 Moist cure the specimens in accordance with Practice D 1632.

6.3 At the end of the moist-cure period, immerse the specimens in water for 4 h.

6.4 Remove the specimens from the water and make compression tests as soon as practicable, keeping specimens moist by a wet burlap or blanket covering.

NOTE 4—Other conditioning procedures, such as air or oven drying, alternate wetting and drying, or alternate freezing and thawing may be specified after an initial moist curing period. Curing and conditioning procedures shall be given in detail in the report.

6.5 Check the smoothness of the faces with a straightedge. If necessary, cap the faces to meet the requirements of the section on Capping Specimens of Practice D 1632.

7. Procedure

7.1 Place the lower bearing block on the table or platen of the testing machine directly under the spherically seated (upper) bearing block. Place the specimen on the lower bearing block, making certain that the vertical axis of the specimen is aligned with the center of thrust of the spherically seated block. As this block is brought to bear on the specimen, rotate its movable portion gently by hand so that uniform seating is obtained.

7.2 Apply the load continuously and without shock. A screw power testing machine, with the moving head operating at approximately 0.05 in. (1 mm)/min when the machine is running idle, may be used. With hydraulic machines, adjust the loading to a constant rate within the limits of 20 ± 10 psi (140 ± 70 kPa)/s, depending upon the strength of the specimen. Record the total load at failure of the test specimen to the nearest 10 lbf (40 N).

8. Calculation

8.1 Calculate the unit compressive strength of the specimen by dividing the maximum load by the cross-sectional area.

NOTE 5—If desired, make allowance for the ratio of height to diameter (h/d) by multiplying the compressive strength of Method B specimens by the factor 1.10. This converts the strength for an h/d ratio of 2.00 to that for the h/d ratio of 1.15 commonly used in routine testing of soil-cement (see Section 4). This conversion is based on that given in Method C 42,

[3] For additional discussion on the significance and use of compressive strength results, see the *Soil-Cement Laboratory Handbook* , Chapter 4, Portland Cement Association, Skokie, IL, 1971, pp 31 and 32.

which has been found applicable for soil-cement.

9. Report

9.1 The report shall include the following:

9.1.1 Specimen identification number,

9.1.2 Diameter and height, in. (mm),

9.1.3 Cross-sectional areas, in.^{2} (mm^2),

9.1.4 Maximum load, to the nearest 10 lbf (40 N),

9.1.5 Conversion factor for height to diameter ratio (see Note 4), if used,

9.1.6 Compressive strength, calculated to the nearest 5 psi (35 kPa),

9.1.7 Age of specimen, and

9.1.8 Details of curing and conditioning periods, and water content in accordance with Test Method D 2216 at the time of test.

10. Precision and Bias

10.1 The precision and bias of this test method have not been established by an interlaboratory test program. However, based on the test data that are available, the following may serve as a guide as to the variability of compressive strength test results.

10.1.1 Tests were performed in a single lab on 122 sets of duplicate specimens molded from 21 different soil materials. The average difference in strength on duplicate specimens was 8.1 % and the median difference was 6.2 %. These values are expressed as the percent of the average strength of the two specimens as follows:

$$\% \text{ Difference} = \frac{(\text{high value} - \text{low value})}{(\text{high value} + \text{low value})/2} \times 100 \quad (1)$$

The distribution of the variation is shown in Fig. 1. The data[4,5] cover a wide range of cement contents and compressive strengths.

11. Keywords

11.1 compressive strength; soil-cement; soil stabilization

[4] Packard, R. G., "Alternate Measures for Measuring Freeze-Thaw and Wet-Dry Resistance of Soil-Cement Mixtures," *Highway Research Bulletin*, 353, Transportation Research Board, 1962, pp 8–41.

[5] Packard, R. G., and Chapman, G. A., "Developments in Durability Testing of Soil-Cement Mixtures," Highway Research Record No. 36, Transportation Research Board, 1963, pp 97–122.

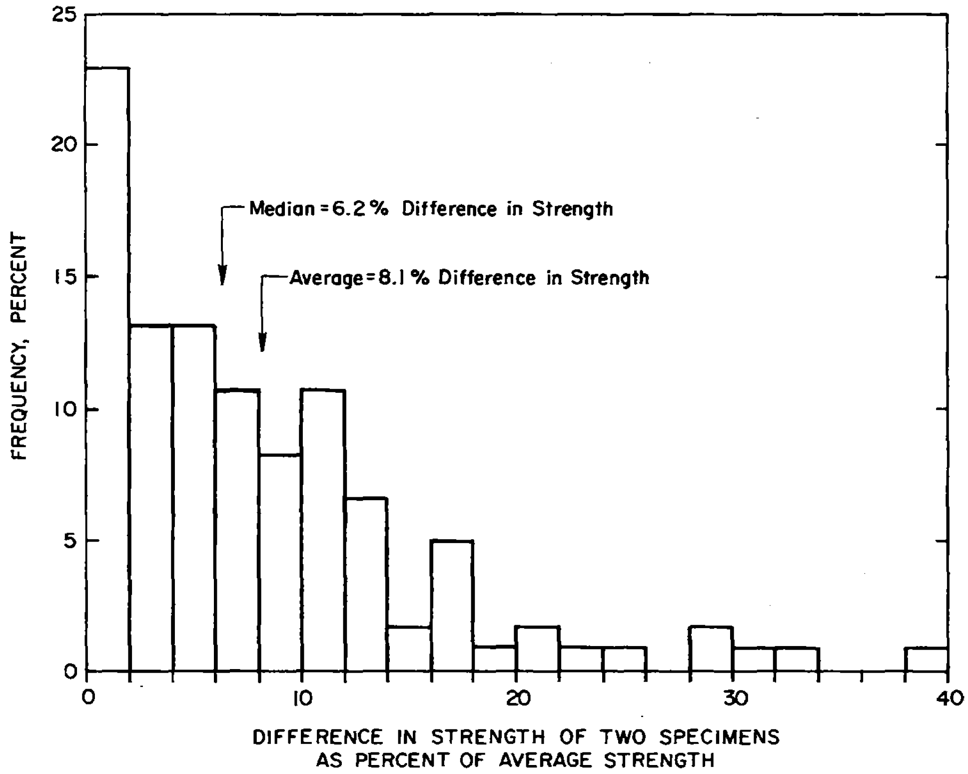

FIG. 1 Distribution of Variation of Test Results for 122 Sets of Duplicate Specimens

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1996) that may impact the use of this standard.

(*1*) Changed title to clarify that two methods are presented.
(*2*) Added new sentence at the end of 1.2.1 to identify applicable materials.
(*3*) Added a new sentence at the end of 1.2.2 to identify applicable materials.
(*4*) Added new 1.3 to reference Practice D 6026.
(*5*) Revised 1.4 to clarify units used in the test method.
(*6*) Added Terminology D 653, Test Method D 2216, Specification D 4753, and Practice D 6026 to Section 2, Referenced Documents.
(*7*) Added new footnote 4 to reference *Annual Book of ASTM Standards*, Vol 04.09 and renumbered the remaining footnotes.
(*8*) Added new Section 3 on Terminology. Renumbered remaining sections.
(*9*) Added reference to Test Method D 2216 in 9.1.8.
(*10*) Changed "crushing" to "shearing" in 4.2.
(*11*) Changed "moisture" to "water" in 9.1.8.
(*12*) Prepared new Summary of Changes.