Anexo No. 01: Matriz de consistencia

Matriz de consistencia

Tema: "EFECTOS DE LA ADICIÓN DE MUCÍLAGO DE *Cactaceae* COLUMNAR EN LAS PROPIEDADES MECÁNICAS DEL CONCRETO HIDRÁULICO PARA SU APLICACIÓN EN PAVIMENTOS RÍGIDOS EN LA CIUDAD DE JULIACA - 2022."

PROBLEMAS DE LA INVESTIGACIÓN	OBJETIVOS DE LA INVESTIGACIÓN	HIPOTESIS DE LA INVESTIGACIÖN	VARIABLES E INDICADORES	METODOLOGÍA DE LA INVESTIGACIÓN
Problema general ¿Cuáles son los efectos que tiene la adición de mucílago de cactaceae columnar en las propiedades mecánicas del concreto hidráulico para su aplicación en pavimentos rígidos en la ciudad de Juliaca - 2022? **Problemas específicos.** • ¿Cuál es el efecto que tiene la adición de mucílago de cactaceae columnar en la resistencia a la compresión axial? • ¿Cuál es el efecto que tiene la adición de mucílago de cactaceae columnar en la resistencia a la flexión? • ¿Qué efecto tiene la adición de mucilago de cactaceae columnar en la trabajabilidad del concreto hidráulico? • ¿Cuál es el efecto que tiene la adición de mucílago de cactaceae columnar en la trabajabilidad?	**Objetivo General.** Determinar los efectos que tiene la adición de mucílago de cactaceae columnar en las propiedades mecánicas del concreto hidráulico para su aplicación en pavimentos rígidos en la ciudad de Juliaca-Puno, 2022. **Objetivos Específicos.** • Determinar los efectos de la adición de mucílago de cactaceae columnar en la resistencia a la compresión axiall. • Determinar los efectos de la adición de mucílago de cactaceae columnar en la resistencia a la flexión. • Determinar los efectos de la adición de mucílago de cactaceae columnar en la trabajabilidad. • Determinar los efectos de la adición de mucílago de cactaceae columnar en la permeabilidad. • Proponer el espesor de losa de pavimento óptimo mediante la metodología AASHTO-93 a partir de los resultados de las propiedades mecánicas del concreto hidráulico con la adición de mucílago de cactaceae columnar.	**Hipótesis General.** La adición de mucílago de cactaceae columnar influye directamente en las propiedades mecánicas del concreto hidráulico para su aplicación en pavimentos rígidos de la ciudad de Juliaca-Puno 2022. **Hipótesis Específicas.** • La adición de mucílago de cactaceae columnar al concreto hidráulico influye directamente en la resistencia a la compresión axia. • La adición de mucílago de cactaceae columnar al concreto hidráulico influye directamente en la resistencia a la flexión. • La adición de mucílago de cactaceae columnar al concreto influye directamente en la trabajabilidad. • La adición de mucílago de cactaceae columnar al concreto influye de manera favorable en la permeabilidad.	**Variable Independiente.** X1: Mucilago de cactaceae columnar **Indicadores.** Dosificación con respecto al Peso en kilogramos del cemento - 1% - 2% - 3% **Variables Dependientes.** Y1: Resistencia a la compresión Y2: Resistencia a la flexión Y3: Trabajabilidad Y4: Permeabilidad Y5: Espesor de losa de pavimento	**LINEA DE INVESTIGACION** Construcciones y Gerencia **DISEÑO DE INVESTIGACIÓN** TIPO DE INVESTIGACION Enfoque: Investigación Cuantitativa. NIVEL DE INVESTIGACIÓN Explicativa SEGÚN EL GRADO DE MANIPULACIÓN DE VARIABLES diseños experimentales - Cuasi Experimental **POBLACIÓN Y MUESTRA** La población del presente estudio es el concreto estándar f'c=280kg/cm2 (sin la incorporación de mucilago de cactaceae columnar) y el concreto de f'c=280kg/cm2 con la incorporación en distintas proporciones de mucilago de cactaceae columnar. La muestra fue de 9 testigos cilíndricos de un concreto estándar de f'c=280kg/cm2, 27 testigos cilíndricos de un concreto de f'c=280kg/cm2 adicionado de mucilago de cactaceae columnar (con diferentes dosis), así como también 3 viguetas prismáticas de un concreto patrón de f'c=280kg/cm2 y 9 viguetas prismáticas de un concreto de f'c=280kg/cm2 con la incorporación de mucilago de cactaceae columnar (en distintos porcentajes). Igualmente 12 muestras cilíndricas para ensayo de permeabilidad. Haciendo un total de 60 muestras. **TÉCNICAS** Observación directa, análisis de documentos, ensayos de probetas cilíndricas y viguetas con y sin adición de mucilago de cactaceae columnar

Anexo No. 02: Operacionalización de variables

VARIABLES	DEFINICIÓN	DIMENSIONES	INDICADORES	INSTRUMENTO	ESCALA DE MEDICIÓN
Variable independiente: Aditivo natural Mucilago de Cactaceae columnar.	El mucilago es una sustancia viscosa resultado de la biotransformación de plantas de familia de las cactáceae.	Porcentaje en peso del cemento del aditivo natural mucilago de Cactaceae	- 1% - 2% - 3%	Ficha de recolección de datos, Balanza electrónica.	Razón.
Variables dependientes: propiedades del concreto	Las propiedades del concreto fresco son la trabajabilidad, las propiedades del concreto endurecido son la resistencia a la compresión, flexión y a la permeabilidad del concreto.	Propiedades Físicas y Mecánicas del concreto	Trabajabilidad, Resistencia a la compresión, resistencia a la flexión, permeabilidad del concreto.	Ensayo de Cono de Abrahams, Ensayo de resistencia a la compresión, resistencia a la flexión y ensayo de permeabilidad.	De razón.

Anexo No. 03: Caracterización del Mucilago de Cactaceae

Universidad Nacional del Altiplano - Puno

FACULTAD DE INGENIERÍA QUÍMICA

FACULTAD ACREDITADA

LABORATORIO DE CONTROL DE CALIDAD

Nº 001496

LQ - 2022

Certificado de Análisis

ASUNTO : **Agua F.Q. MUCILAGO DE CACTACEAE**

PROCEDENCIA : SECTOR CHOCO,DISTRITO DE AZANGARO, PROVINCIA DE PUNO

PROYECTO : EFECTO DE LA ADICIÒN DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACIÒN

INTERESADO : JOSUE LINO CACERES SONCCO

MUESTREO : 25/04/2019, por el interesado

F. RECEPCIÒN : 25/04/2022

ANÁLISIS : 25/04/2022

COD. MUESTRA : B009-000325

CARACTERÍSTICAS FISICO - QUÍMICAS

PARAMETROS FISICO QUIMICOS	RESULTADOS		METODO ANALITICO
Potencial de Hidrogeno	4.29		Electrométrico
CALCIO (CaO)	82.41 ppm	8.241%	ASTM C25-96
HIERRO (Fe2O3)	0.91	0.000091	Volumétrico
IONES DE MAGNESIO	53.01	0.0053	Volumétrico
IONES DE CLORURO	631.90	0.0631	Volumétrico
IONES DE SULFATOS	154.80	0.0154	Espectrofotometría

Puno, C.U. 12 de mayo del 2022.

VºBº

ING. LUZ MARINA TEVES PONCE
ANALISTA DE LABORATORIO DE CONTROL DE CALIDAD
FIQ - UNA - CIP - 105390

Walther B. Aparicio Aragón. Ph.D.
DECANO - FIQ - UNA

Universidad Nacional del Altiplano - Puno

FACULTAD DE INGENIERÍA QUÍMICA

FACULTAD ACREDITADA

LABORATORIO DE CONTROL DE CALIDAD

Certificado de Análisis

Nº 001497

ASUNTO : Análisis **Reológico** de Musilago

PROCEDENCIA : Sector Choco, Distrito de Azángaro, Departamento de Puno

INTERESADO : Josue Lino Caceres Soncco

MOTIVO : Evaluación de Parámetro Reológicos

MUESTREO : 04/05/2022, por el interesado

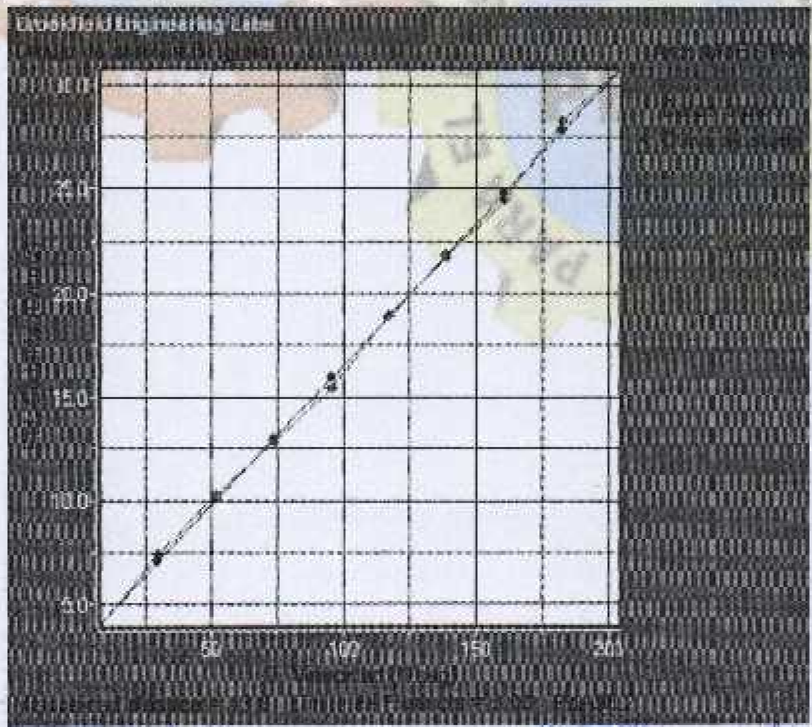
ANÁLISIS : 09/05/2022

COD. MUESTRA : M01

CARACTERISTICAS ESPECÍFICAS

Análisis

Viscosidad (cP)	Velocidad (RPM)	% Par (%)	Esf.Cortante (D/cm^2)	G.Velocidad (1/seg)
049	007	005	004	008
025	025	009	007	030
020	042	013	010	052
017	060	016	013	074
016	078	020	015	095
016	096	024	019	117
016	114	028	022	139
015	131	031	024	161
015	149	036	028	183
015	167	039	031	204



ING. LUZ MARINA TEVES PONCE

Wilson D. Aparicio Aragón Ph.D.
DECANO - FIQ - UNA

Puno, C.U. 11 de Mayo del 2022.

V°B°

MÉTODO DE PRUEBA ESTÁNDAR PARA LA DETERMINACIÓN DE LA GRAVEDAD ESPECÍFICA DE LOS SÓLIDOS
ASTM D854-14

PROYECTO : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

REGISTRO N°: LH22-CERT-127

SOLICITANTE : BACH. JOSUÉ LINO CÁCERES SONCCO

UBICACIÓN DE PROYECTO : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO

MUESTREADO POR : Tesista

FECHA DE ENSAYO : 12/04/2022

TURNO : Diurno

Material : MUCILAGO DE CACTACEAE
Sondaje : ---
N° de Muestra : M-1
Progresiva : ---

MÉTODO DE ENSAYO "B"

Gravedad específica de sólidos	---	1.01
Temperatura del agua destilada durante el ensayo	°C	18.5
Coeficiente de Temperatura (K)	---	1.00030
Gravedad específica de sólidos corregida por T°	---	**1.011**

OBSERVACIONES:

* Muestra tomada en campo por el SOLICITANTE

Washington Rodriguez Olazabal
TEC. SUELOS, CONCRETO Y ASFALTO

LABORATORIO MECÁNICA DE SUELOS, CONCRETO Y ASFALTO — MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH
Juan Manuel Frizancho Aguirre
CIP. 45130
JEFE DE LABORATORIO DE SUELOS Y PAVIMENTOS

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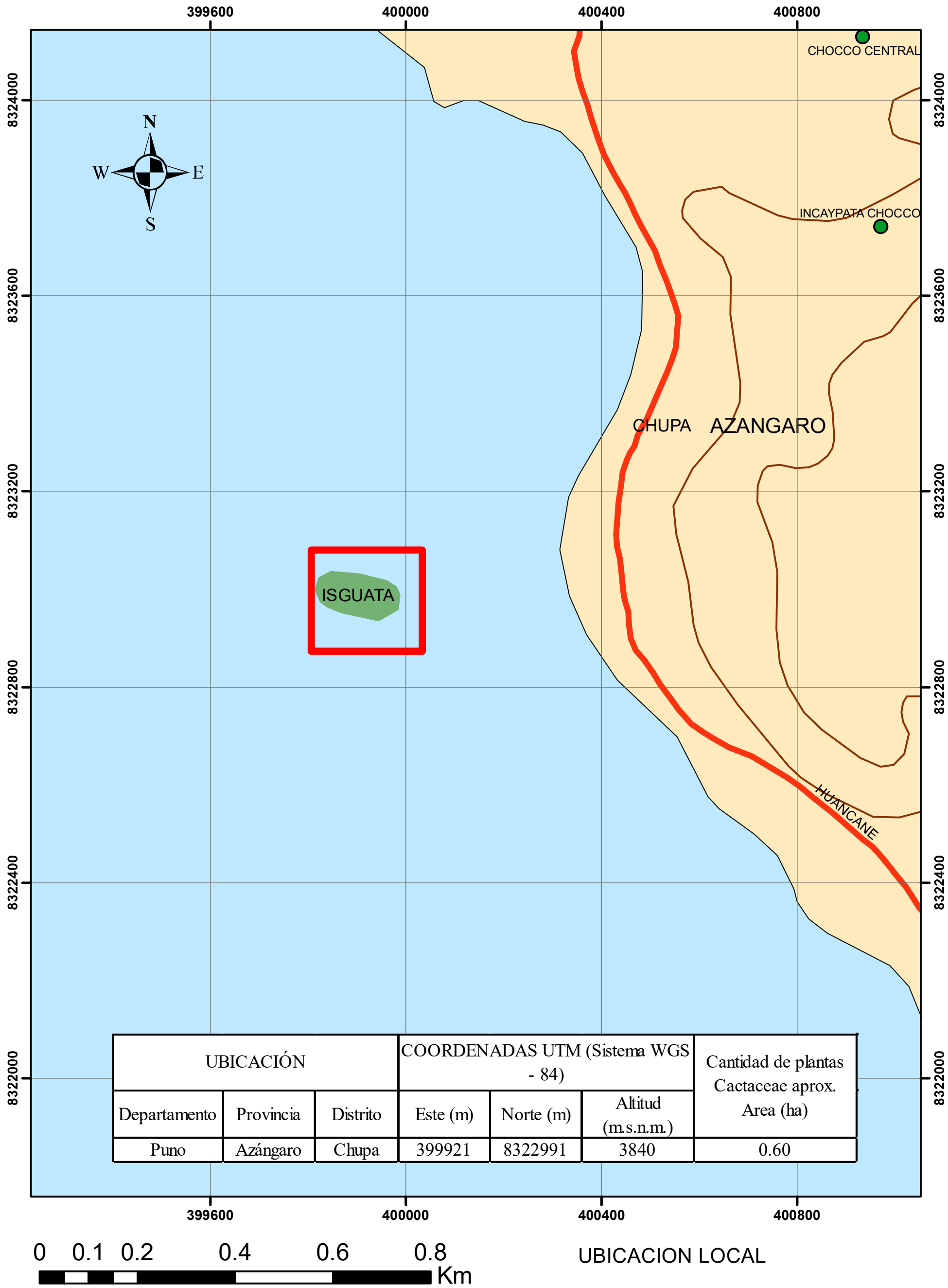
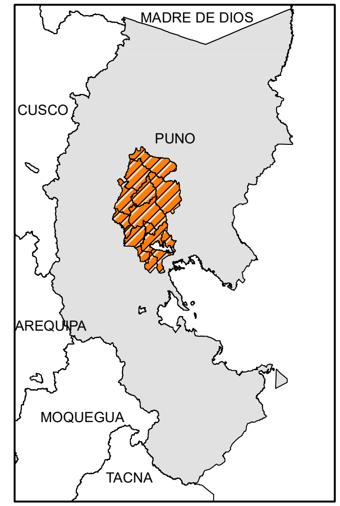


UBICACIÓN			COORDENADAS UTM (Sistema WGS - 84)			Cantidad de plantas Cactaceae aprox. Area (ha)
Departamento	Provincia	Distrito	Este (m)	Norte (m)	Altitud (m.s.n.m.)	
Puno	Azángaro	Chupa	399921	8322991	3840	0.60

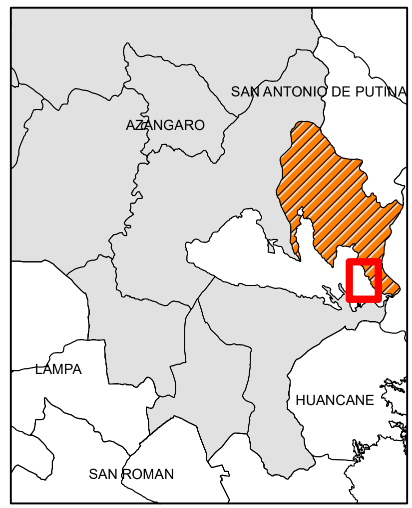
UBICACION LOCAL

UBICACION NACIONAL

UBICACION REGIONAL



UBICACION DISTRITAL



LEYENDA

- CENTRO POBLADO
- RED VIAL REGIONAL
- RED VIAL NACIONAL
- RED VIAL VECINAL
- ISLAS
- LAGOS

UNIVERSIDAD NACIONAL DEL ALTIPLANO	
FACULTAD DE INGENIERÍA CIVIL Y ARQUITECTURA	
ESCUELA PROFESIONAL DE INGENIERÍA CIVIL	
PROYECTO:	EFECTOS DE LA ADICIÓN DE MUCÍLAGO DE Cactaceae COLUMNAR EN LAS PROPIEDADES MECÁNICAS DEL CONCRETO HIDRÁULICO PARA SU APLICACIÓN EN PAVIMENTOS RÍGIDOS EN LA CIUDAD DE JULIACA - 2022
PLANO	UBICACIÓN DE PLANTA CACTACEAE COLUMNAR
FECHA	Jun-22

Anexo No. 04: Ensayo de Agregados

CERTIFICADOS DE CALIDAD

ENSAYO DE AGREGADOS - CANTERA JESERVI (CABANILLAS)

MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH S.A.C.

Laboratorio: Jr. Honduras Urb. Taparachi 1 Sector Mza. B26 Lt. 7B - Juliaca - Puno
Oficinas Principales: Jr. Honduras Mza. B26 Lt. 7B - Cede Juliaca | Jr. Puno N° 633 - Cede Puno
Celular: +51 956 020220 | +51 988 080809 | E-Mail: constructoralh.sac@gmail.com
RUC: 20602295533

CONTENIDO DE HUMEDAD EVAPORABLE DE LOS AGREGADOS

ASTM C566-19

Proyecto : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

REGISTRO N°: LH22-CERT-127

Solicitante : BACH. JOSUÉ LINO CÁCERES SONCCO
Ubicación de Proyecto : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO
Material : Agregado Fino y Agregado Grueso

MUESTREADO POR : Tesista
FECHA DE ENSAYO : 12/04/2022
TURNO : Diurno

Código de Muestra : ---
Procedencia : CANTERA JESERVI (CABANILLAS)
N° de Muestra : ---
Progresiva : ---

CONTENIDO DE HUMEDAD - Agregado Fino

ITEM	DESCRIPCION	UND.	DATOS	CANTERA
1	Peso del Recipiente	g	36.8	JESERVI CABANILLAS
2	Peso del Recipiente + muestra húmeda	g	263.2	
3	Peso del Recipiente + muestra seca	g	251.4	
4	**CONTENIDO DE HUMEDAD**	%	**5.50**	

CONTENIDO DE HUMEDAD - Agregado Grueso

ITEM	DESCRIPCION	UND.	DATOS	CANTERA
1	Peso del Recipiente	g	45.3	JESERVI CABANILLAS
2	Peso del Recipiente + muestra húmeda	g	328.6	
3	Peso del Recipiente + muestra seca	g	317.9	
4	**CONTENIDO DE HUMEDAD**	%	**3.93**	

EQUIPOS UTILIZADOS

#	NOMBRE DEL EQUIPO	MARCA	SERIE	IDENTIFICACIÓN
1	JUEGO DE TAMICES N° 1	FORNEY	---	BS8F
2	BALANZA ELECTRÓNICA	OHAUS	B835336209	MT-LM-300-2021
3	HORNO DE LABORATORIO	A&A INSTRUMENT	190548	MT-LT-115-2021
4	TAMIZ DE LAVADO NO. 200	FORNEY	---	BS8F

MULTISERVICIOS Y CONSTRUCTORA

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DNI. 02436007

LABORATORIO MECÁNICA DE SUELOS, CONCRETO Y ASFALTO

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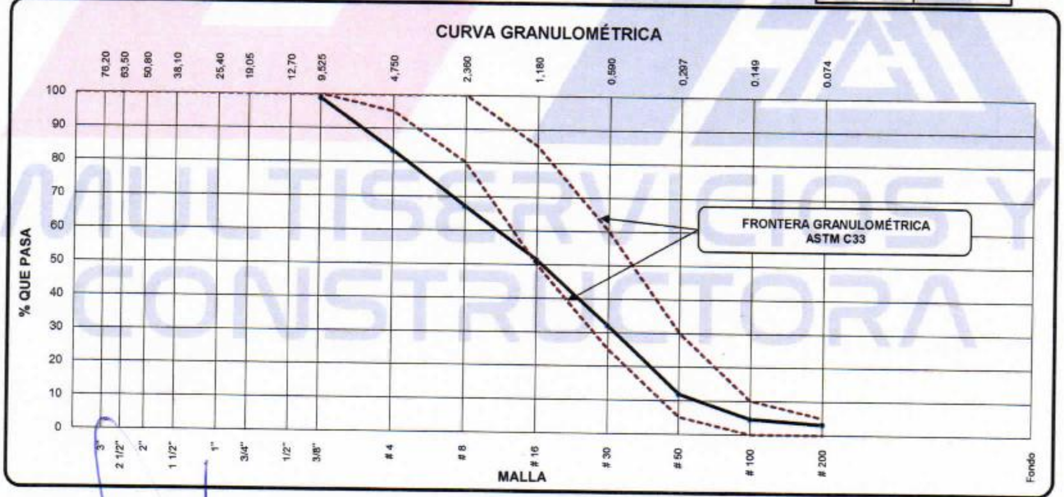
Oficinas Principales: Jr. Honduras Mza. B26 Lt. 7B - Cede Juliaca | Jr. Puno N° 633 - Cede Puno
Celular: +51 956 020220 | +51 988 080809 | E-Mail: constructoralh.sac@gmail.com
RUC: 20602295533

ANÁLISIS GRANULOMÉTRICO DE LOS AGREGADOS
ASTM C136 / C136M - 19

Proyecto	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**Registro N°:**	**LH22-CERT-127**
Solicitante	: BACH. JOSUÉ LINO CÁCERES SONCCO	**Muestreado por :**	Tesista
Ubicación de Proyecto	: DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO	**Fecha de Ensayo:**	12/04/2022
Material	: Agregado Fino	**Turno:**	Diurno
Código de Muestra	: ---	**Peso Inicial :**	500.00
Procedencia	: CANTERA JESERVI (CABANILLAS)	**Peso Lavado :**	482.50
N° de Muestra	: ---		
Progresiva	: ---		

AGREGADO FINO ASTM C33/C33M - 18 - ARENA GRUESA

ABERTURA DE TAMICES Marco de 8" de diámetro		Peso Retenido g	% Parcial Retenido	% Acumulado Retenido	% Acumulado que Pasa	ESPECIFICACIÓN	
Nombre	mm					Mínimo	Máximo
4"	100.00 mm					100.00	100.00
3 1/2"	90.00 mm					100.00	100.00
3"	75.00 mm					100.00	100.00
2 1/2"	63.00 mm					100.00	100.00
2"	50.00 mm					100.00	100.00
1 1/2"	37.50 mm					100.00	100.00
1"	25.00 mm					100.00	100.00
3/4"	19.00 mm					100.00	100.00
1/2"	12.50 mm					100.00	100.00
3/8"	9.50 mm	5.8	1.15	1.15	98.85	100.00	100.00
No. 4	4.75 mm	77.8	15.38	16.53	83.47	95.00	100.00
No. 8	2.36 mm	82.3	16.27	32.80	67.20	80.00	100.00
No. 16	1.18 mm	79.9	15.80	48.60	51.40	50.00	85.00
No. 30	600 µm	97.7	19.32	67.91	32.09	25.00	60.00
No. 50	300 µm	102.1	20.19	88.10	11.90	5.00	30.00
No. 100	150 µm	36.9	7.30	95.39	4.61		10.00
No. 200	75 µm	7.1	1.40	96.80	3.20		5.00
< No. 200	-	16.2	3.20	100.00		-	-
						MF	3.50
						TMN	3/8



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MULTISERVICIOS Y CONSTRUCTORA LH
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CIP. 45130
JEFE DE LABORATORIO DE SUELOS Y PAVIMENTOS

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ANÁLISIS GRANULOMÉTRICO DE LOS AGREGADOS

ASTM C136 / C136M - 19

Proyecto : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

Registro N°: LH22-CERT-127

Solicitante : BACH. JOSUÉ LINO CÁCERES SONCCO

Ubicación de Proyecto : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO

Material : Agregado Grueso

Muestreado por : Tesista

Fecha de Ensayo: 12/04/2022

Turno: Diurno

Código de Muestra : ---

Procedencia : CANTERA JESERVI (CABANILLAS)

N° de Muestra : ---

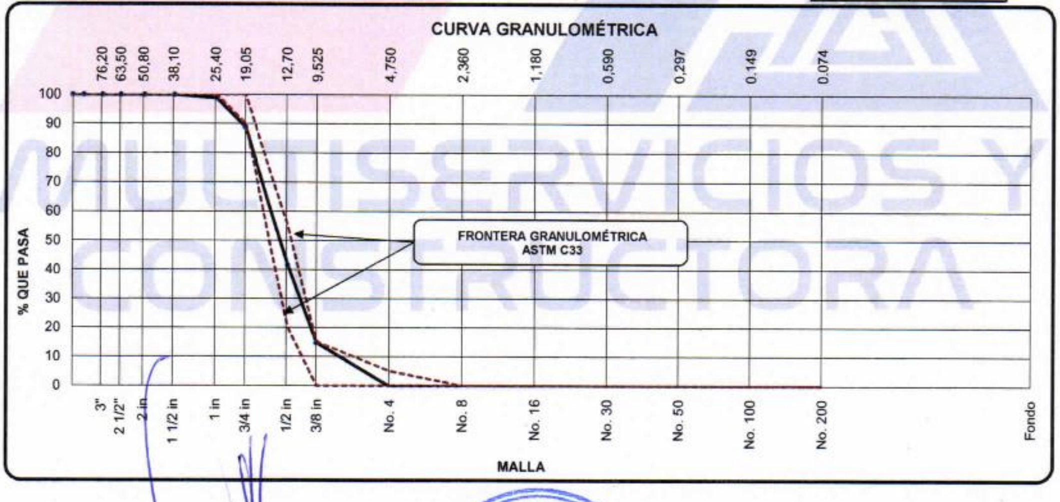
Progresiva : ---

Peso Inicial : 3000.10

Peso Lavado : 3008.70

AGREGADO GRUESO ASTM C33/C33M - 18 - HUSO # 6

ABERTURA DE TAMICES Marco de 8" de diámetro		Peso Retenido g	% Parcial Retenido	% Acumulado Retenido	% Acumulado que Pasa	ESPECIFICACIÓN	
Nombre	mm					Mínimo	Máximo
4 in'	100.00 mm				100.00	100.00	100.00
3 1/2 in	90.00 mm				100.00	100.00	100.00
3 in	75.00 mm				100.00	100.00	100.00
2 1/2 in	63.00 mm				100.00	100.00	100.00
2 in	50.00 mm				100.00	100.00	100.00
1 1/2 in	37.50 mm				100.00	100.00	100.00
1 in	25.00 mm	32.5	1.08	1.08	98.92	100.00	100.00
3/4 in	19.00 mm	299.6	9.99	11.07	88.93	90.00	100.00
1/2 in	12.50 mm	1421.2	47.37	58.44	41.56	20.00	55.00
3/8 in	9.50 mm	806.2	26.87	85.31	14.69		15.00
No. 4	4.75 mm	444.4	14.81	100.13			5.00
No. 8	2.36 mm	4.8	0.16	100.29			
No. 16	1.18 mm	0.7	0.02	100.31			
No. 30	600 µm			100.31			
No. 50	300 µm			100.31			
No. 100	150 µm			100.31			
No. 200	75 µm			100.31			
< No. 200	-			100.00		-	-
						MF	6.98
						TMN	1 in



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DETERMINACIÓN DEL PESO ESPECÍFICO Y ABSORCIÓN DEL AGREGADO FINO

ASTM C128-15

Proyecto : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

Registro N°: LH22-CERT-127

Solicitante : BACH. JOSUÉ LINO CÁCERES SONCCO

Ubicación de Proyecto : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO

Material : Agregado Fino

Muestreado por : Tesista
Fecha de Ensayo: 12/04/2022
Turno: Diurno

Código de Muestra : ---
Procedencia : CANTERA JESERVI (CABANILLAS)
N° de Muestra : ---
Progresiva : ---

	IDENTIFICACIÓN	1	2	
A	Peso Mat. Sat. Sup. Seca (SSS)	500.0	495.0	
B	Peso Frasco + agua	688.9	688.9	
C	Peso Frasco + agua + muestra SSS	992.9	989.9	
D	Peso del Mat. Seco	489.5	484.6	
Pe Bulk (Base seca) o Peso específico de masa = D/(B+A-C)		2.50	2.50	2.497
Pe Bulk (Base Saturada) o Peso específico SSS = A/(B+A-C)		2.55	2.55	2.551
Pe Aparente (Base seca) o Peso específico aparente = D/(B+D-C)		2.64	2.64	2.639
% Absorción = 100*((A-D)/D)		2.1	2.1	2.1

Washington Rodriguez Olazabal
TEC. SUELOS, CONCRETO Y PAVIMENTO
DNI. 02436007

LABORATORIO DE MECÁNICA DE SUELOS, CONCRETO Y ASFALTO — MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH
Juan Manuel Frizancho Aguirre
CIP. 45130
JEFE DE LABORATORIO DE SUELOS Y PAVIMENTOS

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MÉTODO DE PRUEBA ESTÁNDAR PARA LA DENSIDAD RELATIVA (GRAVEDAD ESPECÍFICA) Y LA ABSORCIÓN DE AGREGADOS GRUESOS

ASTM C127-15

Proyecto : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

Registro N°: LH22-CERT-127

Solicitante : BACH. JOSUÉ LINO CÁCERES SONCCO

Ubicación de Proyecto : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO

Material : Agregado Grueso

Muestreado por : Tesista

Fecha de Ensayo: 12/04/2022

Turno: Diurno

Código de Muestra : ---

Procedencia : CANTERA JESERVI (CABANILLAS)

N° de Muestra : ---

Progresiva : ---

	DATOS	A	B
1	Peso de la muestra sss	2036.4	1657.2
2	Peso de la muestra sss sumergida	1249.0	1016.4
3	Peso de la muestra secada al horno	2001.2	1628.6

RESULTADOS	1	2	PROMEDIO
PESO ESPECIFICO DE MASA	2.542	2.542	**2.542**
PESO ESPECIFICO DE MASA S.S.S	2.586	2.586	**2.586**
PESO ESPECIFICO APARENTE	2.660	2.660	**2.660**
PORCENTAJE DE ABSORCIÓN (%)	1.8	1.8	**1.8**

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DETERMINACIÓN DEL PESO UNITARIO SUELTO Y COMPACTADO DE LOS AGREGADOS

ASTM C29 / C29M - 17a

Proyecto : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

Registro N°: LH22-CERT-127

Solicitante : BACH. JOSUÉ LINO CÁCERES SONCCO
Ubicación de Proyecto : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO
Material : Agregado Fino

Muestreado por : Tesista
Fecha de Ensayo: 12/04/2022
Turno: Diurno

Código de Muestra : ---
Procedencia : CANTERA JESERVI (CABANILLAS)
N° de Muestra : ---
Progresiva : ---

PESO UNITARIO SUELTO

IDENTIFICACIÓN	1	2	PROMEDIO
Peso de molde (g)	8000	8000	
Volumen de molde (cm3)	3048	3048	
Peso de molde + muestra suelta (g)	**12909**	**12906**	
Peso de muestra suelta (g)	4909	4906	
PESO UNITARIO SUELTO (kg/m3)	1611	1610	**1610**

PESO UNITARIO COMPACTADO

IDENTIFICACIÓN	1	2	PROMEDIO
Peso de molde (g)	8000	8000	
Volumen de molde (cm3)	3048	3048	
Peso de molde + muestra consolidada (g)	**13340**	**13304**	
Peso de muestra suelta (g)	5340	5304	
PESO UNITARIO COMPACTADO (kg/m3)	1752	1740	**1746**

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DETERMINACIÓN DEL PESO UNITARIO SUELTO Y COMPACTADO DE LOS AGREGADOS

ASTM C29 / C29M - 17a

Proyecto : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

Registro N°: LH22-CERT-127

Solicitante : BACH. JOSUÉ LINO CÁCERES SONCCO
Ubicación de Proyecto : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO
Material : Agregado Grueso

Muestreado por : Tesista
Fecha de Ensayo: 12/04/2022
Turno: Diurno

Código de Muestra : ---
Procedencia : CANTERA JESERVI (CABANILLAS)
N° de Muestra : ---
Progresiva : ---

PESO UNITARIO SUELTO

IDENTIFICACIÓN	1	2	PROMEDIO
Peso de molde (g)	8000	8000	
Volumen de molde (cm3)	3048	3048	
Peso de molde + muestra suelta (g)	12071	12003	
Peso de muestra suelta (g)	4071	4003	
PESO UNITARIO SUELTO (kg/m3)	1336	1313	1324

PESO UNITARIO COMPACTADO

IDENTIFICACIÓN	1	2	PROMEDIO
Peso de molde (g)	8000	8000	
Volumen de molde (cm3)	3048	3048	
Peso de molde + muestra consolidada (g)	12525	12501	
Peso de muestra suelta (g)	4525	4501	
PESO UNITARIO COMPACTADO (kg/m3)	1485	1477	1481

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Anexo No. 05: Diseño de mezcla

CERTIFICADOS DE CALIDAD

(DISEÑO DE MEZCLA - $f'c$ = 280 kg/cm^2 + 0.0% MUCÍLAGO DE CACTACEAE)

MULTISERVICIOS Y CONSTRUCTORA

DISEÑO DE MEZCLAS DE CONCRETO f'c = 280 Kg/cm2

ACI 211.1

Proyecto : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022 — **REGISTRO N°:** LH22-CERT-127

Solicitante : BACH. JOSUÉ LINO CÁCERES SONCCO — **MUESTREADO POR :** Tesista

Ubicación de Proyecto : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO — **FECHA DE ELABORACIÓN :** 13/04/2022

Agregado : Ag. Grueso / Ag. Fino — **F'c de diseño:** 280 kg/cm2

Procedencia : Agregado Grueso: CANTERA JESERVI (CABANILLAS) / Agregado Fino: CANTERA JESERVI (CABANA) — **Asentamiento:** 3" - 4"

Cemento : Cemento RUMI IP Clasico — **Código de mezcla:** PATRON

1. RESISTENCIA PROMEDIO A LA COMPRESIÓN REQUERIDA

F'cr = 364 kg/cm2

2. RELACIÓN AGUA CEMENTO

R a/c = 0.45

R a/cte = No aplica

3. DETERMINACIÓN DEL VOLUMEN DE AGUA

Agua = 193 L

4. CANTIDAD DE AIRE ATRAPADO

Aire = 1.5%

5. CÁLCULO DE LA CANTIDAD DE CEMENTO

Cemento = 427 kg

= 10.0 Bolsas x m^3

6. ADICIONES

Adición: No aplica

7. FIBRAS

Fibras: No aplica

8. ADITIVOS

Aditivo Mucílago: No aplica

9. CÁLCULO DEL VOLUMEN DE AGREGADOS

INSUMO		PESO ESPECÍFICO	VOLUMEN ABSOLUTO
Cemento RUMI IP Clasico		2800 kg/m3	0.1524 m3
Agua		1000 kg/m3	0.1930 m3
Aire atrapado ≈ 1.5%		---	0.0150 m3
Adición		No aplica	0.0000 m3
Aditivo Mucílago	0.00%	No aplica	0.0000 m3
Agregado Grueso		2586 kg/m3	0.3454 m3
Agregado Fino		2551 kg/m3	0.2942 m3
		Volumen de pasta =	0.3604 m3
		Volumen de agregados =	0.6396 m3

	HUMEDAD	ABSORCIÓN	MÓD. FINEZA	P.U. SUELTO	P.U. COMPACTADO	TMN
Agregado Grueso	3.9%	1.8%	6.98	1324	1481	1 "
Agregado Fino	5.5%	2.1%	3.50	1610	1746	3/8"

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DISEÑO DE MEZCLAS DE CONCRETO f'c = 280 Kg/cm2

ACI 211.1

Proyecto : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022 — **REGISTRO N°:** LH22-CERT-127

Solicitante : BACH. JOSUÉ LINO CÁCERES SONCCO — **MUESTREADO POR :** Tesista

Ubicación de Proyecto : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO — **FECHA DE ELABORACIÓN :** 13/04/2022

Agregado : Ag. Grueso / Ag. Fino — **F'c de diseño:** 280 kg/cm2

Procedencia : Agregado Grueso: CANTERA JESERVI (CABANILLAS) / Agregado Fino: CANTERA JESERVI (CABANILLAS) — **Asentamiento:** 3" - 4"

Cemento : Cemento RUMI IP Clasico — **Código de mezcla:** PATRON

10. PROPORCIÓN DE AGREGADOS SECOS

Agregado Grueso	54.0%	≈ 0.3454 m3	≈ 893 kg
Agregado Fino	46.0%	≈ 0.2942 m3	≈ 751 kg

11. PESO HÚMEDO DE LOS AGREGADOS - CORRECCIÓN POR HUMEDAD

Agregado Grueso	928 kg
Agregado Fino	792 kg

12. AGUA EFECTIVA CORREGIDA POR ABSORCIÓN Y HUMEDAD

Agua 148 L

13. PROPORCIÓN EN VOLUMEN DE OBRA

Cemento RUMI IP Clasico	Agregado Fino	Agregado Grueso	Agua	Aditivo Mucílago
1	1.7	2.5	14.8 L	0.000 kg

14. RESUMEN DE PROPORCIONES EN PESO

COMPONENTE	PESO SECO	PESO HÚMEDO
Cemento RUMI IP Clasico	427 kg	427 kg
Agua	193 L	148 kg
Aire atrapado ≈ 1.5%	0.0 kg	0.0 kg
Adición	0.0 kg	0.0 kg
Aditivo Mucílago	0.0 kg	0.0 kg
Agregado Grueso	893 kg	928 kg
Agregado Fino	751 kg	792 kg
PUT	2264 kg	2295 kg

CANTIDADES DE PROBETAS PARA PRUEBA

Probetas 6 x 12	: 9
Probetas 4 x 8	: 2
Vigas	: 2
PUC	: 1
SLUMP	: 1

15. TANDA DE PRUEBA MÍNIMA — 0.105 m3

COMPONENTE	PESO HÚMEDO
Cemento RUMI IP Clasico	44.696 kg
Agua	15.549 L
Aire atrapado ≈ 1.5%	0 kg
Adición	0 kg
Aditivo Mucílago	0 g
Agregado Adicional	97.208 kg
Agregado Grueso	82.916 kg
Agregado Fino	0 kg
Fibras	0 kg
Slump obtenido	3
Apariencia	Aceptable
Rendimiento	1.01

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LABORATORIO — MULTISERVICIOS Y CONSTRUCTORA — MECÁNICA DE SUELOS, CONCRETO Y ASFALTO

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CERTIFICADOS DE CALIDAD

(DISEÑO DE MEZCLA - $f'c$ = 280 kg/cm^2 + 1.0% MUCÍLAGO DE CACTACEAE)

MULTISERVICIOS Y CONSTRUCTORA

DISEÑO DE MEZCLAS DE CONCRETO f'c = 280 Kg/cm2

ACI 211.1

Proyecto	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
Solicitante	: BACH. JOSUÉ LINO CÁCERES SONCCO	**MUESTREADO POR :**	Tesista
Ubicación de Proyecto	: DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO	**FECHA DE ELABORACIÓN :**	13/04/2022
Agregado	: Ag. Grueso / Ag. Fino	**F'c de diseño:**	280 kg/cm2
Procedencia	: Agregado Grueso: CANTERA JESERVI (CABANILLAS) / Agregado Fino: CANTERA JESERVI (CABANILLAS)	**Asentamiento:**	3" - 4"
Cemento	: Cemento RUMI IP Clasico	**Código de mezcla:**	**1% Mucílago**

1. RESISTENCIA PROMEDIO A LA COMPRESIÓN REQUERIDA

F´cr = 364 kg/cm2

2. RELACIÓN AGUA CEMENTO

R a/c = 0.45 R a/cte = No aplica

3. DETERMINACIÓN DEL VOLUMEN DE AGUA

Agua = 193 L

4. CANTIDAD DE AIRE ATRAPADO

Aire = 1.5%

5. CÁLCULO DE LA CANTIDAD DE CEMENTO

Cemento = 427 kg
= 10.0 Bolsas x m^3

6. ADICIONES

Adición No aplica

7. FIBRAS

Fibras No aplica

8. ADITIVOS

Aditivo Mucílago = 4.3 kg

9. CÁLCULO DEL VOLUMEN DE AGREGADOS

INSUMO		PESO ESPECÍFICO	VOLUMEN ABSOLUTO
Cemento RUMI IP Clasico		2800 kg/m3	0.1524 m3
Agua		1000 kg/m3	0.1930 m3
Aire atrapado = 1.5%		---	0.0150 m3
Adición		No aplica	0.0000 m3
Aditivo Mucílago	1.00%	1011 kg/m3	0.0042 m3
Agregado Grueso		2586 kg/m3	0.3240 m3
Agregado Fino		2551 kg/m3	0.3113 m3
		Volumen de pasta =	0.3647 m3
		Volumen de agregados =	0.6353 m3

	HUMEDAD	ABSORCIÓN	MÓD. FINEZA	P.U. SUELTO	P.U. COMPACTADO	TMN
Agregado Grueso	3.9%	1.8%	6.98	1324	1481	1 "
Agregado Fino	5.5%	2.1%	3.50	1610	1746	3/8"

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MULTISERVICIOS Y CONSTRUCTORA LH S.A.C.

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Oficinas Principales: Jr. Honduras Mza. B26 Lt. 7B - Cede Juliaca | Jr. Puno N° 633 - Cede Puno
Celular: +51 956 020220 | +51 988 080809 | E-Mail: constructoralh.sac@gmail.com
RUC: 20602295533

DISEÑO DE MEZCLAS DE CONCRETO f'c = 280 Kg/cm2

ACI 211.1

Proyecto	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
Solicitante	: BACH. JOSUÉ LINO CÁCERES SONCCO	**MUESTREADO POR :**	Tesista
Ubicación de Proyecto	: DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO	**FECHA DE ELABORACIÓN :**	13/04/2022
Agregado	: Ag. Grueso / Ag. Fino	**F'c de diseño:**	280 kg/cm2
Procedencia	: Agregado Grueso: CANTERA JESERVI (CABANILLAS) / Agregado Fino: CANTERA JESERVI (CABANILLAS)	**Asentamiento:**	3" - 4"
Cemento	: Cemento RUMI IP Clasico	**Código de mezcla:**	**1% Mucílago**

10. PROPORCIÓN DE AGREGADOS SECOS

Agregado Grueso	51.0%	≈ 0.3240 m3	≈ 838 kg
Agregado Fino	49.0%	≈ 0.3113 m3	≈ 794 kg

11. PESO HÚMEDO DE LOS AGREGADOS - CORRECCIÓN POR HUMEDAD

Agregado Grueso	871 kg
Agregado Fino	838 kg

12. AGUA EFECTIVA CORREGIDA POR ABSORCIÓN Y HUMEDAD

Agua	148 L

13. PROPORCIÓN EN VOLUMEN DE OBRA

Cemento RUMI IP Clasico	Agregado Fino	Agregado Grueso	Agua	Aditivo Mucílago
1	**1.8**	**2.3**	**14.8 L**	**0.425 kg**

14. RESUMEN DE PROPORCIONES EN PESO

COMPONENTE	PESO SECO	PESO HÚMEDO
Cemento RUMI IP Clasico	427 kg	427 kg
Agua	193 L	148 kg
Aire atrapado ≈ 1.5%	0.0 kg	0.0 kg
Adición	0.0 kg	0.0 kg
Aditivo Mucílago	4.3 kg	4.3 kg
Agregado Grueso	838 kg	871 kg
Agregado Fino	794 kg	838 kg
PUT	2256 kg	2288 kg

CANTIDADES DE PROBETAS PARA PRUEBA

Probetas 6 x 12	:	9
Probetas 4 x 8	:	2
Vigas	:	2
PUC	:	1
SLUMP	:	1

15. TANDA DE PRUEBA MÍNIMA — 0.105 m3

COMPONENTE	PESO HÚMEDO
Cemento RUMI IP Clasico	44.696 kg
Agua	15.521 L
Aire atrapado ≈ 1.5%	0 kg
Adición	0 kg
Aditivo Mucílago	0.447 g
Agregado Adicional	91.202 kg
Agregado Grueso	87.741 kg
Agregado Fino	0 kg
Fibras	0 kg
Slump obtenido	**3 1/2**
Apariencia	**Aceptable**
Rendimiento	**1.00**

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DNI. 02436007

LABORATORIO — MULTISERVICIOS Y CONSTRUCTORA — MECÁNICA DE SUELOS, CONCRETO Y ASFALTO

MULTISERVICIOS Y CONSTRUCTORA LH
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CERTIFICADOS DE CALIDAD

(DISEÑO DE MEZCLA - $f'c$ = 280 kg/cm^2 + 2.0% MUCÍLAGO DE CACTACEAE)

MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH S.A.C.

MULTISERVICIOS Y CONSTRUCTORA

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RUC: 20602295533

DISEÑO DE MEZCLAS DE CONCRETO f'c = 280 Kg/cm2

ACI 211.1

Proyecto	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
Solicitante	: BACH. JOSUÉ LINO CÁCERES SONCCO	**MUESTREADO POR :**	Tesista
Ubicación de Proyecto	: DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO	**FECHA DE ELABORACIÓN :**	13/04/2022
Agregado	: Ag. Grueso / Ag. Fino	**F'c de diseño:**	280 kg/cm2
Procedencia	: Agregado Grueso: CANTERA JESERVI (CABANILLAS) / Agregado Fino: CANTERA JESERVI (CABANA)	**Asentamiento:**	3" - 4"
Cemento	: Cemento RUMI IP Clasico	**Código de mezcla:**	**2% Mucílago**

1. RESISTENCIA PROMEDIO A LA COMPRESIÓN REQUERIDA

F´cr = 364 kg/cm2

2. RELACIÓN AGUA CEMENTO

R a/c = 0.45   R a/cte = No aplica

3. DETERMINACIÓN DEL VOLUMEN DE AGUA

Agua = 193 L

4. CANTIDAD DE AIRE ATRAPADO

Aire = 1.5%

5. CÁLCULO DE LA CANTIDAD DE CEMENTO

Cemento = 427 kg

= 10.0 Bolsas x m^3

6. ADICIONES

Adición   No aplica

7. FIBRAS

Fibras   No aplica

8. ADITIVOS

Aditivo Mucilago   = 8.5 kg

9. CÁLCULO DEL VOLUMEN DE AGREGADOS

INSUMO		PESO ESPECÍFICO	VOLUMEN ABSOLUTO
Cemento RUMI IP Clasico		2800 kg/m3	0.1524 m3
Agua		1000 kg/m3	0.1930 m3
Aire atrapado ≈ 1.5%		---	0.0150 m3
Adición		No aplica	0.0000 m3
Aditivo Mucílago	2.00%	1011 kg/m3	0.0084 m3
Agregado Grueso		2586 kg/m3	0.3219 m3
Agregado Fino		2551 kg/m3	0.3093 m3
		Volumen de pasta =	0.3689 m3
		Volumen de agregados =	0.6311 m3

	HUMEDAD	ABSORCIÓN	MÓD. FINEZA	P.U. SUELTO	P.U. COMPACTADO	TMN
Agregado Grueso	3.9%	1.8%	6.98	1324	1481	1 "
Agregado Fino	5.5%	2.1%	3.50	1610	1746	3/8"

Washington Rodríguez Olazabal
TEC. SUELOS, CONCRETO Y PAVIMENTO
DNI. 02436007

LABORATORIO MECÁNICA DE SUELOS, CONCRETO Y ASFALTO
MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH
Juan Manuel Frizancho Aguirre
CIP. 45130
JEFE DE LABORATORIO DE SUELOS Y PAVIMENTOS

PROHIBIDA LA REPRODUCCIÓN TOTAL O PARCIAL DE ESTE DOCUMENTO SIN AUTORIZACIÓN ESCRITA DEL LABORATORIO MULTISERVICIOS Y CONSTRUCTORA LH S.A.C., ASÍ MISMO CARECE DE INVALIDES SIN EL SELLO Y FIRMA.

DISEÑO DE MEZCLAS DE CONCRETO f'c = 280 Kg/cm2

ACI 211.1

Proyecto	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
Solicitante	: BACH. JOSUÉ LINO CÁCERES SONCCO	**MUESTREADO POR :**	Tesista
Ubicación de Proyecto	: DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO	**FECHA DE ELABORACIÓN :**	13/04/2022
Agregado	: Ag. Grueso / Ag. Fino	**F'c de diseño:**	280 kg/cm2
Procedencia	: Agregado Grueso: CANTERA JESERVI (CABANILLAS) / Agregado Fino: CANTERA JESERVI (CABANILLAS)	**Asentamiento:**	3" - 4"
Cemento	: Cemento RUMI IP Clasico	**Código de mezcla:**	**2% Mucílago**

10. PROPORCIÓN DE AGREGADOS SECOS

Agregado Grueso	51.0%	≈ 0.3219 m3	≈ 832 kg
Agregado Fino	49.0%	≈ 0.3093 m3	≈ 789 kg

11. PESO HÚMEDO DE LOS AGREGADOS - CORRECCIÓN POR HUMEDAD

Agregado Grueso	865 kg
Agregado Fino	832 kg

12. AGUA EFECTIVA CORREGIDA POR ABSORCIÓN Y HUMEDAD

Agua	149 L

13. PROPORCIÓN EN VOLUMEN DE OBRA

Cemento RUMI IP Clasico	Agregado Fino	Agregado Grueso	Agua	Aditivo Mucílago
1	**1.8**	**2.3**	**14.8 L**	**0.850 kg**

14. RESUMEN DE PROPORCIONES EN PESO

COMPONENTE	PESO SECO	PESO HÚMEDO
Cemento RUMI IP Clasico	427 kg	427 kg
Agua	193 L	149 kg
Aire atrapado ≈ 1.5%	0.0 kg	0.0 kg
Adición	0.0 kg	0.0 kg
Aditivo Mucílago	8.5 kg	8.5 kg
Agregado Grueso	832 kg	865 kg
Agregado Fino	789 kg	832 kg
PUT	2250 kg	2281 kg

CANTIDADES DE PROBETAS PARA PRUEBA

Probetas 6 x 12	:	9
Probetas 4 x 8	:	2
Vigas	:	2
PUC	:	1
SLUMP	:	1

15. TANDA DE PRUEBA MÍNIMA — 0.105 m3

COMPONENTE	PESO HÚMEDO
Cemento RUMI IP Clasico	44.696 kg
Agua	15.552 L
Aire atrapado ≈ 1.5%	0 kg
Adición	0 kg
Aditivo Mucílago	0.894 g
Agregado Adicional	90.596 kg
Agregado Grueso	87.158 kg
Agregado Fino	0 kg
Fibras	0 kg
Slump obtenido	**5 1/2**
Apariencia	**Fluida**
Rendimiento	**1.01**

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LABORATORIO DE SUELOS, CONCRETO Y ASFALTO — MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH
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CERTIFICADOS DE CALIDAD

(DISEÑO DE MEZCLA - $f'c$ = 280 kg/cm^2 + 3.0% MUCÍLAGO DE CACTACEAE)

MULTISERVICIOS Y CONSTRUCTORA

DISEÑO DE MEZCLAS DE CONCRETO f'c = 280 Kg/cm2

ACI 211.1

Proyecto : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022 — **REGISTRO N°:** LH22-CERT-127

Solicitante : BACH. JOSUÉ LINO CÁCERES SONCCO — **MUESTREADO POR :** Tesista

Ubicación de Proyecto : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO — **FECHA DE ELABORACIÓN :** 13/04/2022

Agregado : Ag. Grueso / Ag. Fino — **F'c de diseño:** 280 kg/cm2

Procedencia : Agregado Grueso: CANTERA JESERVI (CABANILLAS) / Agregado Fino: CANTERA JESERVI (CABANILLAS) — **Asentamiento:** 3" - 4"

Cemento : Cemento RUMI IP Clasico — **Código de mezcla:** 3% Mucílago

1. RESISTENCIA PROMEDIO A LA COMPRESIÓN REQUERIDA

F´cr = 364 kg/cm2

2. RELACIÓN AGUA CEMENTO

R a/c = 0.45

R a/cte = No aplica

3. DETERMINACIÓN DEL VOLUMEN DE AGUA

Agua = 193 L

4. CANTIDAD DE AIRE ATRAPADO

Aire = 1.5%

5. CÁLCULO DE LA CANTIDAD DE CEMENTO

Cemento = 427 kg

= 10.0 Bolsas x m^3

6. ADICIONES

Adición: No aplica

7. FIBRAS

Fibras: No aplica

8. ADITIVOS

Aditivo Mucílago = 12.8 kg

9. CÁLCULO DEL VOLUMEN DE AGREGADOS

INSUMO		PESO ESPECÍFICO	VOLUMEN ABSOLUTO
Cemento RUMI IP Clasico		2800 kg/m3	0.1524 m3
Agua		1000 kg/m3	0.1930 m3
Aire atrapado ≈ 1.5%		---	0.0150 m3
Adición		No aplica	0.0000 m3
Aditivo Mucílago	3.00%	1011 kg/m3	0.0127 m3
Agregado Grueso		2586 kg/m3	0.3197 m3
Agregado Fino		2551 kg/m3	0.3072 m3
		Volumen de pasta =	0.3731 m3
		Volumen de agregados =	0.6269 m3

	HUMEDAD	ABSORCIÓN	MÓD. FINEZA	P.U. SUELTO	P.U. COMPACTADO	TMN
Agregado Grueso	3.9%	1.8%	6.98	1324	1481	1 "
Agregado Fino	5.5%	2.1%	3.50	1610	1746	3/8"

Washington Rodríguez Olazabal
TEC. SUELOS, CONCRETO Y PAVIMENTO
DNI. 02436007

LABORATORIO MECÁNICA DE SUELOS, CONCRETO Y ASFALTO — MULTISERVICIOS Y CONSTRUCTORA

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MULTISERVICIOS Y CONSTRUCTORA LH S.A.C.

MULTISERVICIOS Y CONSTRUCTORA

Laboratorio: Jr. Honduras Urb. Taparachi 1 Sector Mza. B26 Lt. 7B - Juliaca - Puno
Oficinas Principales: Jr. Honduras Mza. B26 Lt. 7B - Cede Juliaca | Jr. Puno N° 633 - Cede Puno
Celular: +51 956 020220 | +51 988 080809 | E-Mail: constructoralh.sac@gmail.com
RUC: 20602295533

DISEÑO DE MEZCLAS DE CONCRETO f'c = 280 Kg/cm2

ACI 211.1

Proyecto	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
Solicitante	: BACH. JOSUÉ LINO CÁCERES SONCCO	**MUESTREADO POR :**	Tesista
Ubicación de Proyecto	: DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO	**FECHA DE ELABORACIÓN :**	13/04/2022
Agregado	: Ag. Grueso / Ag. Fino	**F'c de diseño:**	280 kg/cm2
Procedencia	: Agregado Grueso: CANTERA JESERVI (CABANILLAS) / Agregado Fino: CANTERA JESERVI (	**Asentamiento:**	3" - 4"
Cemento	: Cemento RUMI IP Clasico	**Código de mezcla:**	**3% Mucílago**

10. PROPORCIÓN DE AGREGADOS SECOS

Agregado Grueso	51.0%	≈ 0.3197 m3	≈ 827 kg
Agregado Fino	49.0%	≈ 0.3072 m3	≈ 784 kg

11. PESO HÚMEDO DE LOS AGREGADOS - CORRECCIÓN POR HUMEDAD

Agregado Grueso	859 kg
Agregado Fino	827 kg

12. AGUA EFECTIVA CORREGIDA POR ABSORCIÓN Y HUMEDAD

Agua 149 L

13. PROPORCIÓN EN VOLUMEN DE OBRA

Cemento RUMI IP Clasico	Agregado Fino	Agregado Grueso	Agua	Aditivo Mucílago
1	1.8	2.3	14.8 L	1.275 kg

14. RESUMEN DE PROPORCIONES EN PESO

COMPONENTE	PESO SECO	PESO HÚMEDO
Cemento RUMI IP Clasico	427 kg	427 kg
Agua	193 L	149 kg
Aire atrapado ≈ 1.5%	0.0 kg	0.0 kg
Adición	0.0 kg	0.0 kg
Aditivo Mucílago	12.8 kg	12.8 kg
Agregado Grueso	827 kg	859 kg
Agregado Fino	784 kg	827 kg
PUT	2243 kg	2274 kg

CANTIDADES DE PROBETAS PARA PRUEBA

Probetas 6 x 12	:	9
Probetas 4 x 8	:	2
Vigas	:	2
PUC	:	1
SLUMP	:	1

15. TANDA DE PRUEBA MÍNIMA — 0.105 m3

COMPONENTE	PESO HÚMEDO
Cemento RUMI IP Clasico	44.696 kg
Agua	15.583 L
Aire atrapado ≈ 1.5%	0 kg
Adición	0 kg
Aditivo Mucílago	1.341 g
Agregado Adicional	89.99 kg
Agregado Grueso	86.575 kg
Agregado Fino	0 kg
Fibras	0 kg
Slump obtenido	7
Apariencia	**Fluida**
Rendimiento	**1.01**

Washington Rodriguez Olazabal
TEC. SUELOS, CONCRETO Y PAVIMENTO
DNI. 02436007

LABORATORIO — MULTISERVICIOS Y CONSTRUCTORA — SUELOS, CONCRETO Y ASFALTO

MULTISERVICIOS Y CONSTRUCTORA LH
Juan Manuel Frizancho Aguirre
CIP. 45130
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Anexo No. 06: Ensayo de control de concreto fresco

CERTIFICADOS DE CALIDAD

(ENSAYO DE CONTROL DE CONCRETO FRESCO)

MULTISERVICIOS Y CONSTRUCTORA

ENSAYOS DE CONTROL DEL CONCRETO EN ESTADO FRESCO
DISEÑO DE MEZCLAS DE CONCRETO 280 kg/cm2

PROYECTO : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

REGISTRO N°: LH22-CERT-127

SOLICITANTE : BACH. JOSUÉ LINO CÁCERES SONCCO
MUESTREADO POR : Tesista

UBICACIÓN DE PROYECTO : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO
FECHA DE ENSAYO : 13/04/2022

Agregado : Ag. Grueso / Ag. Fino
F'c de diseño: 280 kg/cm2

Procedencia : Agregado Grueso: CANTERA JESERVI (CABANILLAS) / Agregado Fino: CANTERA JESERVI (CA
Asentamiento: 3" - 4"

Cemento : Cemento RUMI IP Clasico
Código de mezcla: PATRON

1. MEDICIÓN DE TEMPERATURA

ASTM C1064 / C1064M - 17

Temperatura Ambiente (°C)	**: 16.30**	**°C**
Temperatura del Concreto (°C)	**: 21.50**	**°C**

Según ACI 318-14
Temperatura Maxima del Concreto = 32 °C
Cumple... !

2. MEDICIÓN DEL ASENTAMIENTO DEL CONCRETO

ASTM C143 / C143M - 20

Slump o Revenimiento	**: 3**	**Pulg.**

Asentamiento de Diseño = 3" a 4"
Cumple... !

3. MEDICIÓN DEL PESO UNITARIO DEL CONCRETO

ASTM C138 / C138M - 17a

Peso Molde	: 3.537	Kg.
Volumen del Molde	: 0.007	m3
Peso de Molde + Concreto Compactado	: 19.639	Kg.
Peso del Concreto	: 16.102	Kg.
Peso Unitario del Concreto (PUC)	**: 2252**	**Kg/m3**

4. MEDICIÓN DEL RENDIMIENTO DEL CONCRETO

ASTM C138 / C138M - 17a

Peso Unitario del Concreto (PUC)	: 2252	Kg/m3
Peso Unitario Teorico (PUT)	: 2264	Kg/m3
Rendimiento del concreto	**: 1.01**	

Rango de Rendimiento 0.98 - 1.02
Cumple... !

5. MEDICIÓN DEL CONTENIDO DE AIRE DEL CONCRETO

ASTM C231 / C231M - 17a

Contenido de Aire Atrapado de Diseño	: 1.5	%
Contenido de Aire (Olla Whashington)	: 1.5	%

OBSERVACIONES:
* Muestras provistas e identificadas por el solicitante
* Los valores presentados en el presente informe son tal cual se obtuvieron en el Laboratorio

Washington Rodriguez Olazabal
TEC. SUELOS, CONCRETO Y PAVIMENTO
DNI. 02436007

LABORATORIO MECÁNICA DE SUELOS, CONCRETO Y ASFALTO — MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH
Juan Manuel Frizancho Aguirre
CIP. 45130
JEFE DE LABORATORIO DE SUELOS Y PAVIMENTOS

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ENSAYOS DE CONTROL DEL CONCRETO EN ESTADO FRESCO
DISEÑO DE MEZCLAS DE CONCRETO 280 kg/cm2

PROYECTO	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
SOLICITANTE	: BACH. JOSUÉ LINO CÁCERES SONCCO	**MUESTREADO POR :**	Tesista
UBICACIÓN DE PROYECTO	: DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO	**FECHA DE ENSAYO :**	13/04/2022
Agregado	: Ag. Grueso / Ag. Fino	**F'c de diseño:**	280 kg/cm2
Procedencia	: Agregado Grueso: CANTERA JESERVI (CABANILLAS) / Agregado Fino: CANTERA JESERVI (CA	**Asentamiento:**	3" - 4"
Cemento	: Cemento RUMI IP Clasico	**Código de mezcla:**	**1% Mucílago**

1. MEDICIÓN DE TEMPERATURA

ASTM C1064 / C1064M - 17

Temperatura Ambiente (°C)	**: 17.30**	**°C**
Temperatura del Concreto (°C)	**: 22.90**	**°C**

Según ACI 318-14
Temperatura Maxima del Concreto = 32 °C
Cumple... !

2. MEDICIÓN DEL ASENTAMIENTO DEL CONCRETO

ASTM C143 / C143M - 20

Slump o Revenimiento	**: 3 1/2**	**Pulg.**

Asentamiento de Diseño = 3" a 4"
Cumple... !

3. MEDICIÓN DEL PESO UNITARIO DEL CONCRETO

ASTM C138 / C138M - 17a

Peso Molde	: 3.537	Kg.
Volumen del Molde	: 0.007	m3
Peso de Molde + Concreto Compactado	: 19.609	Kg.
Peso del Concreto	: 16.072	Kg.
Peso Unitario del Concreto (PUC)	**: 2248**	**Kg/m3**

4. MEDICIÓN DEL RENDIMIENTO DEL CONCRETO

ASTM C138 / C138M - 17a

Peso Unitario del Concreto (PUC)	: 2248	Kg/m3
Peso Unitario Teorico (PUT)	: 2256	Kg/m3
Rendimiento del concreto	**: 1.00**	

Rango de Rendimiento 0.98 - 1.02
Cumple... !

5. MEDICIÓN DEL CONTENIDO DE AIRE DEL CONCRETO

ASTM C231 / C231M - 17a

Contenido de Aire Atrapado de Diseño	: 1.5	%
Contenido de Aire (Olla Whashington)	: 1.5	%

OBSERVACIONES:
* Muestras provistas e identificadas por el solicitante
* Los valores presentados en el presente informe son tal cual se obtuvieron en el Laboratorio

Washington Rodriguez Olazabal
TEC. SUELOS, CONCRETO Y PAVIMENTO
DNI. 02436007

LABORATORIO MECÁNICA DE SUELOS, CONCRETO Y ASFALTO
MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH
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MULTISERVICIOS Y CONSTRUCTORA LH S.A.C.
Laboratorio: Jr. Honduras Urb. Taparachi 1 Sector Mza. B26 Lt. 7B - Juliaca - Puno
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Celular: +51 956 020220 | +51 988 080809 | E-Mail: constructoralh.sac@gmail.com
RUC: 20602295533

ENSAYOS DE CONTROL DEL CONCRETO EN ESTADO FRESCO
DISEÑO DE MEZCLAS DE CONCRETO 280 kg/cm2

PROYECTO : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022 — **REGISTRO N°: LH22-CERT-127**

SOLICITANTE : BACH. JOSUÉ LINO CÁCERES SONCCO — **MUESTREADO POR :** Tesista

UBICACIÓN DE PROYECTO : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO — **FECHA DE ENSAYO :** 13/04/2022

Agregado : Ag. Grueso / Ag. Fino — **F'c de diseño:** 280 kg/cm2

Procedencia : Agregado Grueso: CANTERA JESERVI (CABANILLAS) / Agregado Fino: CANTERA JESERVI (CA **Asentamiento:** 3" - 4"

Cemento : Cemento RUMI IP Clasico — **Código de mezcla:** **2% Mucílago**

1. MEDICIÓN DE TEMPERATURA

ASTM C1064 / C1064M - 17

Temperatura Ambiente (°C)	**: 16.50**	**°C**
Temperatura del Concreto (°C)	**: 20.80**	**°C**

Según ACI 318-14
Temperatura Maxima del Concreto = 32 °C
Cumple... !

2. MEDICIÓN DEL ASENTAMIENTO DEL CONCRETO

ASTM C143 / C143M - 20

Slump o Revenimiento	**: 5 1/2**	**Pulg.**

Asentamiento de Diseño = 3" a 4"
No Cumple... !

3. MEDICIÓN DEL PESO UNITARIO DEL CONCRETO

ASTM C138 / C138M - 17a

Peso Molde	: 3.537	Kg.
Volumen del Molde	: 0.007	m3
Peso de Molde + Concreto Compactado	: 19.529	Kg.
Peso del Concreto	: 15.992	Kg.
Peso Unitario del Concreto (PUC)	**: 2237**	**Kg/m3**

4. MEDICIÓN DEL RENDIMIENTO DEL CONCRETO

ASTM C138 / C138M - 17a

Peso Unitario del Concreto (PUC)	: 2237	Kg/m3
Peso Unitario Teorico (PUT)	: 2250	Kg/m3
Rendimiento del concreto	**: 1.01**	

Rango de Rendimiento 0.98 - 1.02
Cumple... !

5. MEDICIÓN DEL CONTENIDO DE AIRE DEL CONCRETO

ASTM C231 / C231M - 17a

Contenido de Aire Atrapado de Diseño	: 1.5	%
Contenido de Aire (Olla Whashington)	: 1.5	%

OBSERVACIONES:
* Muestras provistas e identificadas por el solicitante
* Los valores presentados en el presente informe son tal cual se obtuvieron en el Laboratorio

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DNI. 02436007

LABORATORIO DE SUELOS, CONCRETO Y ASFALTO — MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH
Juan Manuel Frizancho Aguirre
CIP. 45130
JEFE DE LABORATORIO DE SUELOS Y PAVIMENTOS

PROHIBIDA LA REPRODUCCIÓN TOTAL O PARCIAL DE ESTE DOCUMENTO SIN AUTORIZACIÓN ESCRITA DEL LABORATORIO MULTISERVICIOS Y CONSTRUCTORA LH S.A.C., ASÍ MISMO CARECE DE INVALIDES SIN EL SELLO Y FIRMA.

ENSAYOS DE CONTROL DEL CONCRETO EN ESTADO FRESCO
DISEÑO DE MEZCLAS DE CONCRETO 280 kg/cm2

PROYECTO : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

REGISTRO N°: LH22-CERT-127

SOLICITANTE : BACH. JOSUÉ LINO CÁCERES SONCCO
UBICACIÓN DE PROYECTO : DISTRITO: JULIACA, PROVINCIA: SAN ROMÁN, DEPARTAMENTO: PUNO

MUESTREADO POR : Tesista
FECHA DE ENSAYO : 13/04/2022

Agregado : Ag. Grueso / Ag. Fino
Procedencia : Agregado Grueso: CANTERA JESERVI (CABANILLAS) / Agregado Fino: CANTERA JESERVI (CABA
Cemento : Cemento RUMI IP Clasico

F'c de diseño: 280 kg/cm2
Asentamiento: 3" - 4"
Código de mezcla: **3% Mucilago**

1. MEDICIÓN DE TEMPERATURA

ASTM C1064 / C1064M - 17

Temperatura Ambiente (°C)	**: 13.20**	**°C**
Temperatura del Concreto (°C)	**: 16.90**	**°C**

Según ACI 318-14
Temperatura Maxima del Concreto = 32 °C
Cumple... !

2. MEDICIÓN DEL ASENTAMIENTO DEL CONCRETO

ASTM C143 / C143M - 20

Slump o Revenimiento	**: 7**	**Pulg.**

Asentamiento de Diseño = 3" a 4"
No Cumple... !

3. MEDICIÓN DEL PESO UNITARIO DEL CONCRETO

ASTM C138 / C138M - 17a

Peso Molde	: 3.537	Kg.
Volumen del Molde	: 0.007	m3
Peso de Molde + Concreto Compactado	: 19.417	Kg.
Peso del Concreto	: 15.880	Kg.
Peso Unitario del Concreto (PUC)	**: 2221**	**Kg/m3**

4. MEDICIÓN DEL RENDIMIENTO DEL CONCRETO

ASTM C138 / C138M - 17a

Peso Unitario del Concreto (PUC)	: 2221	Kg/m3
Peso Unitario Teorico (PUT)	: 2243	Kg/m3
Rendimiento del concreto	**: 1.01**	

Rango de Rendimiento 0.98 - 1.02
Cumple... !

5. MEDICIÓN DEL CONTENIDO DE AIRE DEL CONCRETO

ASTM C231 / C231M - 17a

Contenido de Aire Atrapado de Diseño	: 1.5	%
Contenido de Aire (Olla Whashington)	: 1.5	%

OBSERVACIONES:
* Muestras provistas e identificadas por el solicitante
* Los valores presentados en el presente informe son tal cual se obtuvieron en el Laboratorio

Washington Rodriguez Olazabal
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Anexo No. 07: Resultados de resistencia a la compresión

CERTIFICADOS DE CALIDAD

(RESISTENCIA A COMPRESIÓN)

MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH S.A.C.

Laboratorio: Jr. Honduras Urb. Taparachi 1 Sector Mza. B26 Lt. 7B - Juliaca - Puno
Oficinas Principales: Jr. Honduras Mza. B26 Lt. 7B - Cede Juliaca | Jr. Puno N° 633 - Cede Puno
Celular: +51 956 020220 | +51 988 080809 | E-Mail: constructoralh.sac@gmail.com
RUC: 20602295533

MÉTODO DE PRUEBA ESTÁNDAR PARA LA RESISTENCIA A LA COMPRESIÓN DE PROBETAS CILÍNDRICAS DE HORMIGÓN

ASTM C39/C39M-20

PROYECTO : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

REGISTRO N°: LH22-CERT-127

SOLICITANTE : BACH. JOSUÉ LINO CÁCERES SONCCO

UBICACIÓN DE PROYECTO : DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO

FECHA DE EMISIÓN : 11/05/2022

REALIZADO POR : Laboratorio LH

FECHA DE ENSAYO : 20/04/2022

TURNO : Diurno

Tipo de muestra : Concreto endurecido

Presentación : Especímenes cilíndricos 6" x 12"

F'c de diseño : f'c = 280 kg/cm2

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	EDAD (días)	DIÁMETRO (mm)	LONGITUD (mm)	ÁREA (mm^2)	TIPO DE FALLA	FUERZA MÁXIMA (KN)	ESFUERZO Mpa	ESFUERZO kg/cm2
PATRON + 0.0% MUCÍLAGO DE CACTACEAS	13/04/2022	20/04/2022	7	152.5	305.0	18265.4	5	382.78	20.96	213.70
PATRON + 0.0% MUCÍLAGO DE CACTACEAS	13/04/2022	20/04/2022	7	152.4	307.0	18241.5	5	377.47	20.69	211.01
PATRON + 0.0% MUCÍLAGO DE CACTACEAS	13/04/2022	20/04/2022	7	152.5	305.0	18265.4	5	381.62	20.89	213.05

DESVIACION ESTANDAR :	**0.14**	**1.40**
PROMEDIO (Mpa) :	**20.85**	**212.59**
% RESISTENCIA PROMEDIO :	**75.92**	**75.92**
COEFICIENTE DE VARIACION (%) :	**0.66**	**0.66**
RANGO DE VARIACION :	**1.26**	**1.26**

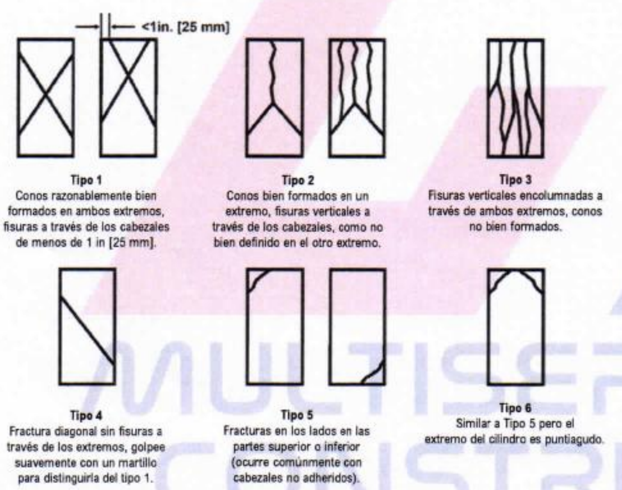

FIG. 2 Esquema de los Modelos de Fractura Tipocos

Fuente: ASTM C39

Si la relación entre la longitud y el diámetro de la muestra es 1,75 o menos, corrija el resultado obtenido en ESFUERZO (Mpa) multiplicando por el factor de corrección apropiado que se muestra en la siguiente tabla:

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

Utilice la interpolación para determinar los factores de corrección para L / D valores entre los dados en la tabla.

Fuente: ASTM C39

	Coeficiente de Variacion	Rango Aceptable de Resistencias de cilindros individuales 2 Cilindros	3 Cilindros
6 a 12 Pulgadas [150 a 300 mm]			
Condiciones de Laboratorio	2.4 %	6.6 %	7.8 %
Condiciones de Campo	2.9 %	8.0 %	9.5 %
4 a 8 Pulgadas [100 a 200 mm]			
Condiciones de Laboratorio	3.2 %	9.0 %	10.6 %

Fuente: ASTM C39

OBSERVACIONES:

* Muestras elaboradas y curadas por el solicitante
* Las muestras cumplen con la relación (altura / diámetro), por lo que no fue necesaria la corrección de esfuerzo

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MÉTODO DE PRUEBA ESTÁNDAR PARA LA RESISTENCIA A LA COMPRESIÓN DE PROBETAS CILÍNDRICAS DE HORMIGÓN

ASTM C39/C39M-20

PROYECTO	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
SOLICITANTE	: BACH. JOSUÉ LINO CÁCERES SONCCO	**REALIZADO POR :**	Laboratorio LH
UBICACIÓN DE PROYECTO	: DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO	**FECHA DE ENSAYO :**	20/04/2022
FECHA DE EMISIÓN	: 11/05/2022	**TURNO :**	Diurno

Tipo de muestra	: Concreto endurecido
Presentación	: Especímenes cilíndricos 6" x 12"
F'c de diseño	: f'c = 280 kg/cm2

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	EDAD (días)	DIÁMETRO (mm)	LONGITUD (mm)	ÁREA (mm^2)	TIPO DE FALLA	FUERZA MÁXIMA (KN)	ESFUERZO Mpa	ESFUERZO kg/cm2
PATRON + 1.0% MUCÍLAGO DE CACTACEAS	13/04/2022	20/04/2022	7	152.4	305.0	18241.5	5	381.42	20.91	213.22
PATRON + 1.0% MUCÍLAGO DE CACTACEAS	13/04/2022	20/04/2022	7	152.3	305.0	18217.5	5	386.78	21.23	216.50
PATRON + 1.0% MUCÍLAGO DE CACTACEAS	13/04/2022	20/04/2022	7	152.4	305.0	18241.5	5	384.38	21.07	214.87

DESVIACION ESTANDAR :	**0.16**	**1.64**
PROMEDIO (Mpa) :	**21.07**	**214.86**
% RESISTENCIA PROMEDIO :	**76.74**	**76.74**
COEFICIENTE DE VARIACION (%) :	**0.76**	**0.76**
RANGO DE VARIACION :	**1.53**	**1.53**

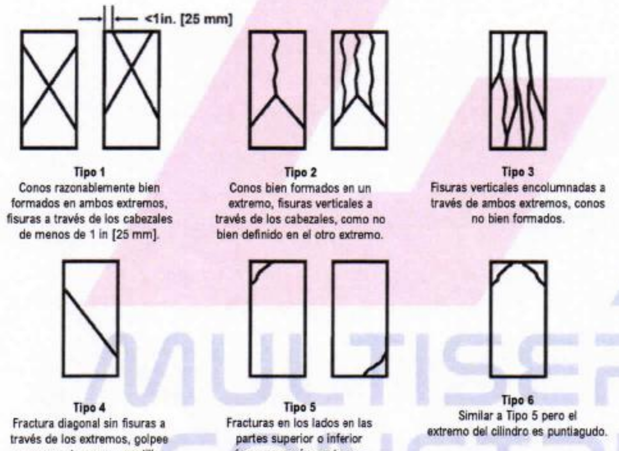

FIG. 2 Esquema de los Modelos de Fractura Tipocos

Fuente: ASTM C39

Si la relación entre la longitud y el diámetro de la muestra es 1,75 o menos, corrija el resultado obtenido en ESFUERZO (Mpa) multiplicando por el factor de corrección apropiado que se muestra en la siguiente tabla:

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

Utilice la interpolación para determinar los factores de corrección para L / D valores entre los dados en la tabla.

Fuente: ASTM C39

	Coeficiente de Variacion	Rango Aceptable de Resistencias de cilindros individuales 2 Cilindros	3 Cilindros
6 a 12 Pulgadas [150 a 300 mm]			
Condiciones de Laboratorio	2.4 %	6.6 %	7.8 %
Condiciones de Campo	2.9 %	8.0 %	9.5 %
4 a 8 Pulgadas [100 a 200 mm]			
Condiciones de Laboratorio	3.2 %	9.0 %	10.6 %

Fuente: ASTM C39

OBSERVACIONES:

* Muestras elaboradas y curadas por el solicitante
* Las muestras cumplen con la relación (altura / diámetro), por lo que no fue necesaria la corrección de esfuerzo

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ASTM C39/C39M-20

PROYECTO	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
SOLICITANTE	: BACH. JOSUÉ LINO CÁCERES SONCCO	**REALIZADO POR :**	Laboratorio LH
UBICACIÓN DE PROYECTO	: DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO	**FECHA DE ENSAYO :**	20/04/2022
FECHA DE EMISIÓN	: 11/05/2022	**TURNO :**	Diurno
Tipo de muestra	: Concreto endurecido		
Presentación	: Especímenes cilíndricos 6" x 12"		
F'c de diseño	: f'c = 280 kg/cm2		

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	EDAD (dias)	DIÁMETRO (mm)	LONGITUD (mm)	ÁREA (mm^2)	TIPO DE FALLA	FUERZA MÁXIMA (KN)	ESFUERZO Mpa	ESFUERZO kg/cm2
PATRON + 2.0% MUCÍLAGO DE CACTACEAS	13/04/2022	20/04/2022	7	152.4	308.0	18241.5	3	386.98	21.21	216.33
PATRON + 2.0% MUCÍLAGO DE CACTACEAS	13/04/2022	20/04/2022	7	152.6	310.0	18289.4	5	386.79	21.15	215.65
PATRON + 2.0% MUCÍLAGO DE CACTACEAS	13/04/2022	20/04/2022	7	152.4	308.0	18241.5	5	387.38	21.24	216.55
								DESVIACION ESTANDAR :	**0.05**	**0.47**
								PROMEDIO (Mpa) :	**21.20**	**216.18**
								% RESISTENCIA PROMEDIO :	**77.21**	**77.21**
								COEFICIENTE DE VARIACION (%) :	**0.22**	**0.22**
								RANGO DE VARIACION :	**0.41**	**0.41**

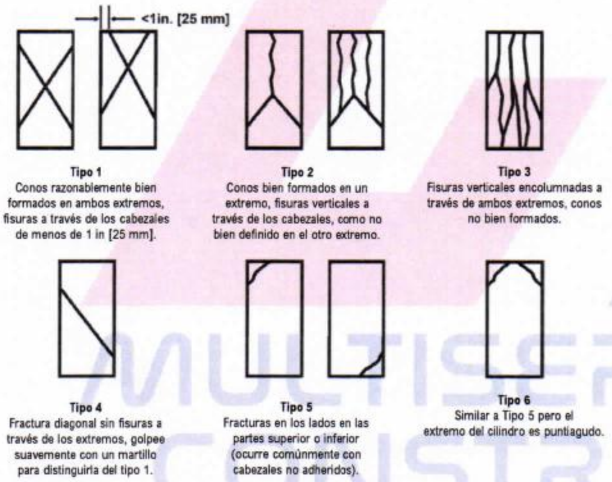

FIG. 2 Esquema de los Modelos de Fractura Tipocos

Fuente: ASTM C39

Si la relación entre la longitud y el diámetro de la muestra es 1,75 o menos, corrija el resultado obtenido en ESFUERZO (Mpa) multiplicando por el factor de corrección apropiado que se muestra en la siguiente tabla:

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

Utilice la interpolación para determinar los factores de corrección para L / D valores entre los dados en la tabla.

Fuente: ASTM C39

	Coeficiente de Variacion	Rango Aceptable de Resistencias de cilindros individuales 2 Cilindros	3 Cilindros
6 a 12 Pulgadas [150 a 300 mm]			
Condiciones de Laboratorio	2.4 %	6.6 %	7.8 %
Condiciones de Campo	2.9 %	8.0 %	9.5 %
4 a 8 Pulgadas [100 a 200 mm]			
Condiciones de Laboratorio	3.2 %	9.0 %	10.6 %

Fuente: ASTM C39

OBSERVACIONES:

* Muestras elaboradas y curadas por el solicitante
* Las muestras cumplen con la relación (altura / diámetro), por lo que no fue necesaria la corrección de esfuerzo

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ASTM C39/C39M-20

PROYECTO	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
SOLICITANTE	: BACH. JOSUÉ LINO CÁCERES SONCCO	**REALIZADO POR :**	Laboratorio LH
UBICACIÓN DE PROYECTO	: DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO	**FECHA DE ENSAYO :**	20/04/2022
FECHA DE EMISIÓN	: 11/05/2022	**TURNO :**	Diurno

Tipo de muestra	: Concreto endurecido
Presentación	: Especímenes cilíndricos 6" x 12"
F'c de diseño	: f'c = 280 kg/cm2

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	EDAD (días)	DIÁMETRO (mm)	LONGITUD (mm)	ÁREA (mm^2)	TIPO DE FALLA	FUERZA MÁXIMA (KN)	ESFUERZO Mpa	ESFUERZO kg/cm2
PATRON + 3.0% MUCÍLAGO DE CACTACEAS	13/04/2022	20/04/2022	7	152.5	308.0	18265.4	3	394.56	21.60	220.27
PATRON + 3.0% MUCÍLAGO DE CACTACEAS	13/04/2022	20/04/2022	7	152.6	308.5	18289.4	5	396.69	21.69	221.17
PATRON + 3.0% MUCÍLAGO DE CACTACEAS	13/04/2022	20/04/2022	7	152.4	308.0	18241.5	3	387.93	21.27	216.86
								DESVIACION ESTANDAR :	**0.22**	**2.28**
								PROMEDIO (Mpa) :	**21.52**	**219.44**
								% RESISTENCIA PROMEDIO :	**78.37**	**78.37**
								COEFICIENTE DE VARIACION (%) :	**1.04**	**1.04**
								RANGO DE VARIACION :	**1.97**	**1.97**

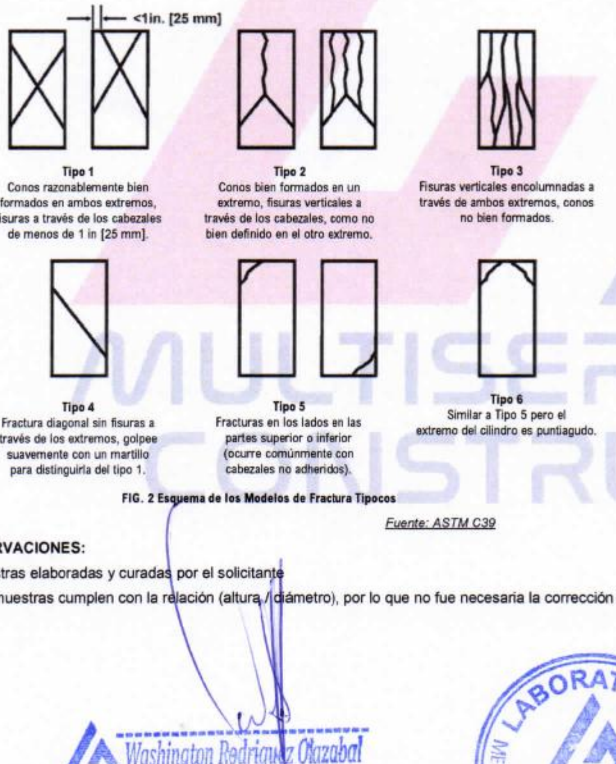

FIG. 2 Esquema de los Modelos de Fractura Tipocos

Fuente: ASTM C39

Si la relación entre la longitud y el diámetro de la muestra es 1,75 o menos, corrija el resultado obtenido en ESFUERZO (Mpa) multiplicando por el factor de corrección apropiado que se muestra en la siguiente tabla:

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

Utilice la interpolación para determinar los factores de corrección para L / D valores entre los dados en la tabla.

Fuente: ASTM C39

	Coeficiente de Variacion	Rango Aceptable de Resistencias de cilindros individuales	
		2 Cilindros	3 Cilindros
6 a 12 Pulgadas [150 a 300 mm]			
Condiciones de Laboratorio	2.4 %	6.6 %	7.8 %
Condiciones de Campo	2.9 %	8.0 %	9.5 %
4 a 8 Pulgadas [100 a 200 mm]			
Condiciones de Laboratorio	3.2 %	9.0 %	10.6 %

Fuente: ASTM C39

OBSERVACIONES:

* Muestras elaboradas y curadas por el solicitante
* Las muestras cumplen con la relación (altura / diámetro), por lo que no fue necesaria la corrección de esfuerzo

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ASTM C39/C39M-20

PROYECTO	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
SOLICITANTE	: BACH. JOSUÉ LINO CÁCERES SONCCO	**REALIZADO POR :**	Laboratorio LH
UBICACIÓN DE PROYECTO	: DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO	**FECHA DE ENSAYO :**	27/04/2022
FECHA DE EMISIÓN	: 11/05/2022	**TURNO :**	Diurno

Tipo de muestra : Concreto endurecido
Presentación : Especímenes cilíndricos 6" x 12"
F'c de diseño : f'c = 280 kg/cm2

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	EDAD (días)	DIÁMETRO (mm)	LONGITUD (mm)	ÁREA (mm^2)	TIPO DE FALLA	FUERZA MÁXIMA (KN)	ESFUERZO Mpa	ESFUERZO kg/cm2
PATRON + 0.0% MUCÍLAGO DE CACTACEAS	13/04/2022	27/04/2022	14	152.5	308.0	18265.4	5	458.16	25.08	255.78
PATRON + 0.0% MUCÍLAGO DE CACTACEAS	13/04/2022	27/04/2022	14	152.5	307.5	18265.4	5	455.30	24.93	254.18
PATRON + 0.0% MUCÍLAGO DE CACTACEAS	13/04/2022	27/04/2022	14	152.5	305.0	18265.4	5	460.82	25.23	257.27
								DESVIACION ESTANDAR :	**0.15**	**1.54**
								PROMEDIO (Mpa) :	**25.08**	**255.74**
								% RESISTENCIA PROMEDIO :	**91.34**	**91.34**
								COEFICIENTE DE VARIACION (%) :	**0.60**	**0.60**
								RANGO DE VARIACION :	**1.20**	**1.20**

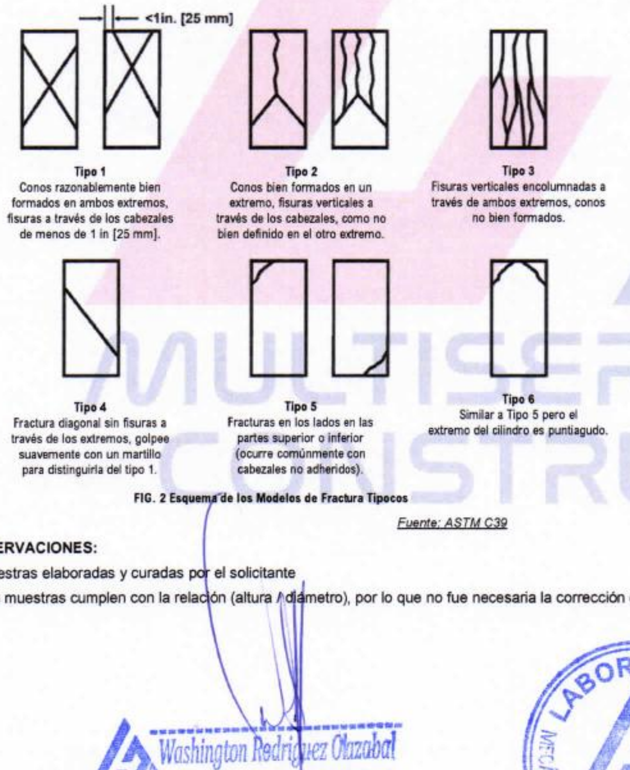

FIG. 2 Esquema de los Modelos de Fractura Tipocos

Fuente: ASTM C39

Si la relación entre la longitud y el diámetro de la muestra es 1,75 o menos, corrija el resultado obtenido en ESFUERZO (Mpa) multiplicando por el factor de corrección apropiado que se muestra en la siguiente tabla:

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

Utilice la interpolación para determinar los factores de corrección para L / D valores entre los dados en la tabla.

Fuente: ASTM C39

	Coeficiente de Variacion	Rango Aceptable de Resistencias de cilindros individuales 2 Cilindros	3 Cilindros
6 a 12 Pulgadas [150 a 300 mm]			
Condiciones de Laboratorio	2.4 %	6.6 %	7.8 %
Condiciones de Campo	2.9 %	8.0 %	9.5 %
4 a 8 Pulgadas [100 a 200 mm]			
Condiciones de Laboratorio	3.2 %	9.0 %	10.6 %

Fuente: ASTM C39

OBSERVACIONES:

* Muestras elaboradas y curadas por el solicitante
* Las muestras cumplen con la relación (altura / diámetro), por lo que no fue necesaria la corrección de esfuerzo

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LABORATORIO MECÁNICA DE SUELOS, CONCRETO Y ASFALTO — MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH
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MULTISERVICIOS Y CONSTRUCTORA LH S.A.C.

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Celular: +51 956 020220 | +51 988 080809 | E-Mail: constructoralh.sac@gmail.com
RUC: 20602295533

MÉTODO DE PRUEBA ESTÁNDAR PARA LA RESISTENCIA A LA COMPRESIÓN DE PROBETAS CILÍNDRICAS DE HORMIGÓN

ASTM C39/C39M-20

PROYECTO : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

REGISTRO N°: LH22-CERT-127

SOLICITANTE : BACH. JOSUÉ LINO CÁCERES SONCCO

UBICACIÓN DE PROYECTO : DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO

FECHA DE EMISIÓN : 11/05/2022

REALIZADO POR : Laboratorio LH

FECHA DE ENSAYO : 27/04/2022

TURNO : Diurno

Tipo de muestra : Concreto endurecido

Presentación : Especímenes cilíndricos 6" x 12"

F'c de diseño : f'c = 280 kg/cm2

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	EDAD (dias)	DIÁMETRO (mm)	LONGITUD (mm)	ÁREA (mm^2)	TIPO DE FALLA	FUERZA MÁXIMA (KN)	ESFUERZO Mpa	ESFUERZO kg/cm2
PATRON + 1.0% MUCÍLAGO DE CACTACEAS	13/04/2022	27/04/2022	14	152.5	306.5	18265.4	5	461.32	25.26	257.55
PATRON + 1.0% MUCÍLAGO DE CACTACEAS	13/04/2022	27/04/2022	14	152.0	307.5	18145.8	5	457.30	25.20	256.98
PATRON + 1.0% MUCÍLAGO DE CACTACEAS	13/04/2022	27/04/2022	14	152.3	307.5	18217.5	5	460.36	25.27	257.68

DESVIACION ESTANDAR :	0.04	0.37
PROMEDIO (Mpa) :	25.24	257.40
% RESISTENCIA PROMEDIO :	91.93	91.93
COEFICIENTE DE VARIACION (%) :	0.14	0.14
RANGO DE VARIACION :	0.27	0.27

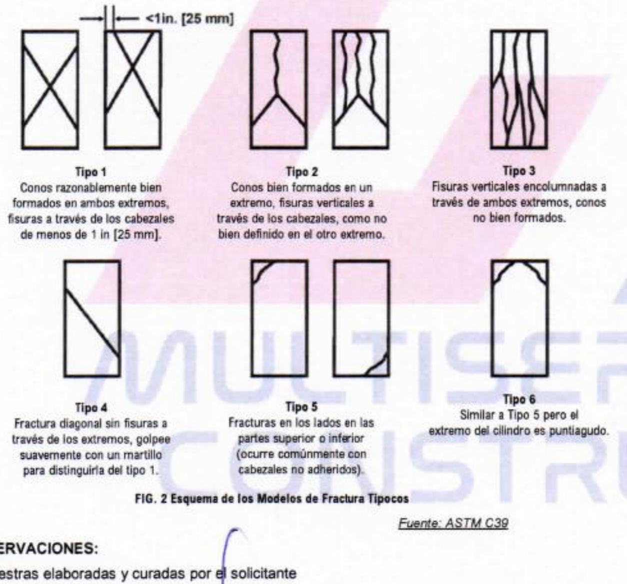

FIG. 2 Esquema de los Modelos de Fractura Tipocos

Fuente: ASTM C39

Si la relación entre la longitud y el diámetro de la muestra es 1,75 o menos, corrija el resultado obtenido en ESFUERZO (Mpa) multiplicando por el factor de corrección apropiado que se muestra en la siguiente tabla:

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

Utilice la interpolación para determinar los factores de corrección para L / D valores entre los dados en la tabla.

Fuente: ASTM C39

	Coeficiente de Variacion	Rango Aceptable de Resistencias de cilindros individuales	
		2 Cilindros	3 Cilindros
6 a 12 Pulgadas [150 a 300 mm]			
Condiciones de Laboratorio	2.4 %	6.6 %	7.8 %
Condiciones de Campo	2.9 %	8.0 %	9.5 %
4 a 8 Pulgadas [100 a 200 mm]			
Condiciones de Laboratorio	3.2 %	9.0 %	10.6 %

Fuente: ASTM C39

OBSERVACIONES:

* Muestras elaboradas y curadas por el solicitante
* Las muestras cumplen con la relación (altura / diámetro), por lo que no fue necesaria la corrección de esfuerzo

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MÉTODO DE PRUEBA ESTÁNDAR PARA LA RESISTENCIA A LA COMPRESIÓN DE PROBETAS CILÍNDRICAS DE HORMIGÓN

ASTM C39/C39M-20

PROYECTO	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
SOLICITANTE	: BACH. JOSUÉ LINO CÁCERES SONCCO	**REALIZADO POR :**	Laboratorio LH
UBICACIÓN DE PROYECTO	: DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO	**FECHA DE ENSAYO :**	27/04/2022
FECHA DE EMISIÓN	: 11/05/2022	**TURNO :**	Diurno
Tipo de muestra	: Concreto endurecido		
Presentación	: Especímenes cilíndricos 6" x 12"		
F'c de diseño	: f'c = 280 kg/cm2		

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	EDAD (días)	DIÁMETRO (mm)	LONGITUD (mm)	ÁREA (mm^2)	TIPO DE FALLA	FUERZA MÁXIMA (KN)	ESFUERZO Mpa	ESFUERZO kg/cm2
PATRON + 2.0% MUCÍLAGO DE CACTACEAS	13/04/2022	27/04/2022	14	152.5	308.0	18265.4	5	464.63	25.44	259.39
PATRON + 2.0% MUCÍLAGO DE CACTACEAS	13/04/2022	27/04/2022	14	152.5	307.5	18265.4	5	462.07	25.30	257.96
PATRON + 2.0% MUCÍLAGO DE CACTACEAS	13/04/2022	27/04/2022	14	152.5	306.5	18265.4	5	466.73	25.55	260.57
								DESVIACION ESTANDAR :	**0.13**	**1.30**
								PROMEDIO (Mpa) :	**25.43**	**259.31**
								% RESISTENCIA PROMEDIO :	**92.61**	**92.61**
								COEFICIENTE DE VARIACION (%) :	**0.50**	**0.50**
								RANGO DE VARIACION :	**1.00**	**1.00**

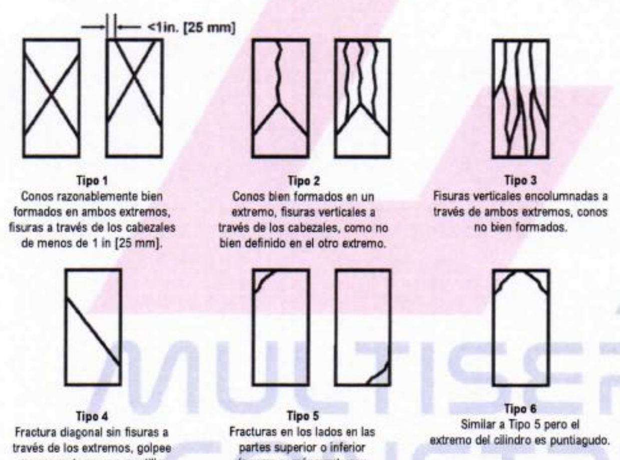

FIG. 2 Esquema de los Modelos de Fractura Tipocos

Fuente: ASTM C39

Si la relación entre la longitud y el diámetro de la muestra es 1,75 o menos, corrija el resultado obtenido en ESFUERZO (Mpa) multiplicando por el factor de corrección apropiado que se muestra en la siguiente tabla:

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

Utilice la interpolación para determinar los factores de corrección para L / D valores entre los dados en la tabla.

Fuente: ASTM C39

	Coeficiente de Variacion	Rango Aceptable de Resistencias de cilindros individuales	
		2 Cilindros	3 Cilindros
6 a 12 Pulgadas [150 a 300 mm]			
Condiciones de Laboratorio	2.4 %	6.6 %	7.8 %
Condiciones de Campo	2.9 %	8.0 %	9.5 %
4 a 8 Pulgadas [100 a 200 mm]			
Condiciones de Laboratorio	3.2 %	9.0 %	10.6 %

Fuente: ASTM C39

OBSERVACIONES:

* Muestras elaboradas y curadas por el solicitante
* Las muestras cumplen con la relación (altura / diámetro), por lo que no fue necesaria la corrección de esfuerzo

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MÉTODO DE PRUEBA ESTÁNDAR PARA LA RESISTENCIA A LA COMPRESIÓN DE PROBETAS CILÍNDRICAS DE HORMIGÓN

ASTM C39/C39M-20

PROYECTO	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
SOLICITANTE	: BACH. JOSUÉ LINO CÁCERES SONCCO	**REALIZADO POR :**	Laboratorio LH
UBICACIÓN DE PROYECTO	: DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO	**FECHA DE ENSAYO :**	27/04/2022
FECHA DE EMISIÓN	: 11/05/2022	**TURNO :**	Diurno

Tipo de muestra	: Concreto endurecido
Presentación	: Especímenes cilíndricos 6" x 12"
F'c de diseño	: f'c = 280 kg/cm2

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	EDAD (dias)	DIÁMETRO (mm)	LONGITUD (mm)	ÁREA (mm^2)	TIPO DE FALLA	FUERZA MÁXIMA (KN)	ESFUERZO Mpa	ESFUERZO kg/cm2
PATRON + 3.0% MUCÍLAGO DE CACTACEAS	13/04/2022	27/04/2022	14	153.5	308.0	18505.7	5	472.47	25.53	260.34
PATRON + 3.0% MUCÍLAGO DE CACTACEAS	13/04/2022	27/04/2022	14	152.8	308.5	18337.4	5	468.98	25.58	260.79
PATRON + 3.0% MUCÍLAGO DE CACTACEAS	13/04/2022	27/04/2022	14	152.6	306.5	18289.4	5	469.15	25.65	261.57
								DESVIACION ESTANDAR :	**0.06**	**0.62**
								PROMEDIO (Mpa) :	**25.59**	**260.90**
								% RESISTENCIA PROMEDIO :	**93.18**	**93.18**
								COEFICIENTE DE VARIACION (%) :	**0.24**	**0.24**
								RANGO DE VARIACION :	**0.47**	**0.47**

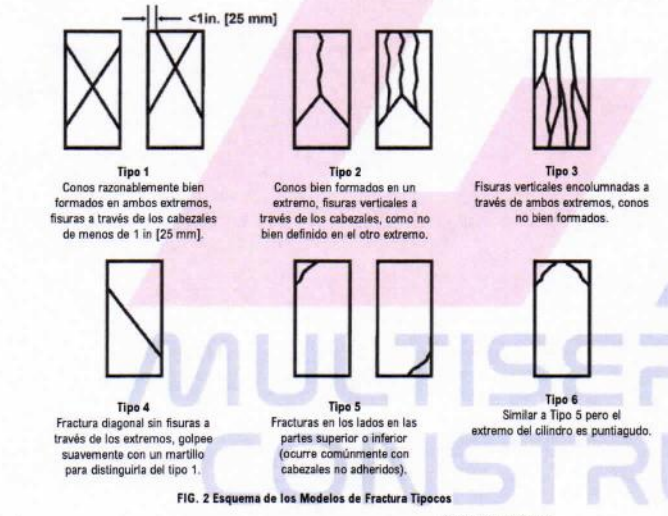

FIG. 2 Esquema de los Modelos de Fractura Tipocos

Fuente: ASTM C39

Si la relación entre la longitud y el diámetro de la muestra es 1,75 o menos, corrija el resultado obtenido en ESFUERZO (Mpa) multiplicando por el factor de corrección apropiado que se muestra en la siguiente tabla:

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

Utilice la interpolación para determinar los factores de corrección para L / D valores entre los dados en la tabla.

Fuente: ASTM C39

	Coeficiente de Variacion	**Rango Aceptable de Resistencias de cilindros individuales**	
		2 Cilindros	**3 Cilindros**
6 a 12 Pulgadas [150 a 300 mm]			
Condiciones de Laboratorio	2.4 %	6.6 %	7.8 %
Condiciones de Campo	2.9 %	8.0 %	9.5 %
4 a 8 Pulgadas [100 a 200 mm]			
Condiciones de Laboratorio	3.2 %	9.0 %	10.6 %

Fuente: ASTM C39

OBSERVACIONES:

* Muestras elaboradas y curadas por el solicitante
* Las muestras cumplen con la relación (altura / diámetro), por lo que no fue necesaria la corrección de esfuerzo

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MÉTODO DE PRUEBA ESTÁNDAR PARA LA RESISTENCIA A LA COMPRESIÓN DE PROBETAS CILÍNDRICAS DE HORMIGÓN

ASTM C39/C39M-20

PROYECTO : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

REGISTRO Nº: LH22-CERT-127

SOLICITANTE : BACH. JOSUÉ LINO CÁCERES SONCCO

REALIZADO POR : Laboratorio LH

UBICACIÓN DE PROYECTO : DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO

FECHA DE ENSAYO : 11/05/2022

FECHA DE EMISIÓN : 11/05/2022

TURNO : Diurno

Tipo de muestra : Concreto endurecido

Presentación : Especímenes cilíndricos 6" x 12"

F'c de diseño : f'c = 280 kg/cm2

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	EDAD (días)	DIÁMETRO (mm)	LONGITUD (mm)	ÁREA (mm^2)	TIPO DE FALLA	FUERZA MÁXIMA (KN)	ESFUERZO Mpa	ESFUERZO kg/cm2
PATRON + 0.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	28	152.6	308.0	18289.4	5	514.00	28.10	286.58
PATRON + 0.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	28	153.7	308.1	18554.0	5	517.31	27.88	284.31
PATRON + 0.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	28	152.4	305.0	18241.5	5	509.65	27.94	284.90

DESVIACION ESTANDAR :	**0.12**	**1.18**
PROMEDIO (Mpa) :	**27.97**	**285.26**
% RESISTENCIA PROMEDIO :	**101.88**	**101.88**
COEFICIENTE DE VARIACION (%) :	**0.41**	**0.41**
RANGO DE VARIACION :	**0.80**	**0.80**

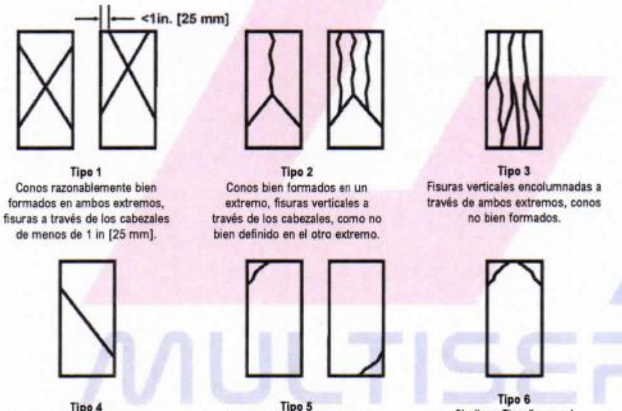

FIG. 2 Esquema de los Modelos de Fractura Tipocos

Fuente: ASTM C39

Si la relación entre la longitud y el diámetro de la muestra es 1,75 o menos, corrija el resultado obtenido en ESFUERZO (Mpa) multiplicando por el factor de corrección apropiado que se muestra en la siguiente tabla:

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

Utilice la interpolación para determinar los factores de corrección para L / D valores entre los dados en la tabla.

Fuente: ASTM C39

	Coeficiente de Variacion	Rango Aceptable de Resistencias de cilindros individuales 2 Cilindros	3 Cilindros
6 a 12 Pulgadas [150 a 300 mm]			
Condiciones de Laboratorio	2.4 %	6.6 %	7.8 %
Condiciones de Campo	2.9 %	8.0 %	9.5 %
4 a 8 Pulgadas [100 a 200 mm]			
Condiciones de Laboratorio	3.2 %	9.0 %	10.6 %

Fuente: ASTM C39

OBSERVACIONES:

* Muestras elaboradas y curadas por el solicitante
* Las muestras cumplen con la relación (altura / diámetro), por lo que no fue necesaria la corrección de esfuerzo

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MÉTODO DE PRUEBA ESTÁNDAR PARA LA RESISTENCIA A LA COMPRESIÓN DE PROBETAS CILÍNDRICAS DE HORMIGÓN

ASTM C39/C39M-20

PROYECTO	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
SOLICITANTE	: BACH. JOSUÉ LINO CÁCERES SONCCO	**REALIZADO POR :**	Laboratorio LH
UBICACIÓN DE PROYECTO	: DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO	**FECHA DE ENSAYO :**	11/05/2022
FECHA DE EMISIÓN	: 11/05/2022	**TURNO :**	Diurno
Tipo de muestra	: Concreto endurecido		
Presentación	: Especímenes cilíndricos 6" x 12"		
F'c de diseño	: f'c = 280 kg/cm2		

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	EDAD (días)	DIÁMETRO (mm)	LONGITUD (mm)	ÁREA (mm^2)	TIPO DE FALLA	FUERZA MÁXIMA (KN)	ESFUERZO Mpa	ESFUERZO kg/cm2
PATRON + 1.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	28	152.2	298.7	18193.6	5	515.61	28.34	288.99
PATRON + 1.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	28	151.7	305.0	18074.3	5	510.09	28.22	287.78
PATRON + 1.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	28	152.4	305.0	18241.5	5	516.86	28.33	288.93

DESVIACION ESTANDAR :	**0.07**	**0.68**
PROMEDIO (Mpa) :	**28.30**	**288.57**
% RESISTENCIA PROMEDIO :	**103.06**	**103.06**
COEFICIENTE DE VARIACION (%) :	**0.24**	**0.24**
RANGO DE VARIACION :	**0.42**	**0.42**

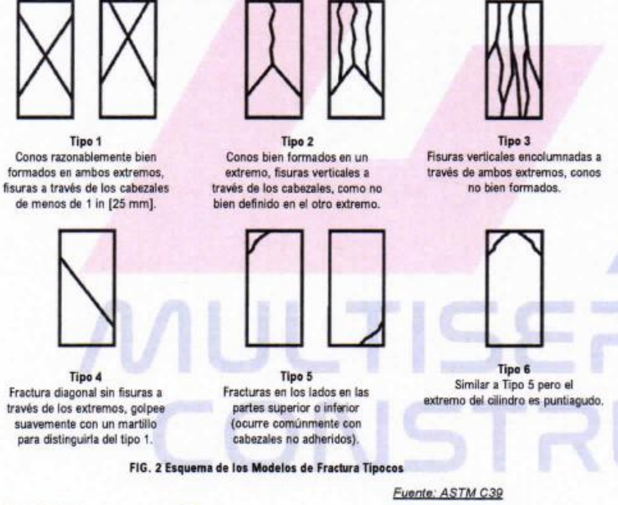

FIG. 2 Esquema de los Modelos de Fractura Tipocos

Fuente: ASTM C39

Si la relación entre la longitud y el diámetro de la muestra es 1,75 o menos, corrija el resultado obtenido en ESFUERZO (Mpa) multiplicando por el factor de corrección apropiado que se muestra en la siguiente tabla:

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

Utilice la interpolación para determinar los factores de corrección para L / D valores entre los dados en la tabla.

Fuente: ASTM C39

	Coeficiente de Variacion	Rango Aceptable de Resistencias de cilindros individuales	
		2 Cilindros	3 Cilindros
6 a 12 Pulgadas [150 a 300 mm]			
Condiciones de Laboratorio	2.4 %	6.6 %	7.8 %
Condiciones de Campo	2.9 %	8.0 %	9.5 %
4 a 8 Pulgadas [100 a 200 mm]			
Condiciones de Laboratorio	3.2 %	9.0 %	10.6 %

Fuente: ASTM C39

OBSERVACIONES:

* Muestras elaboradas y curadas por el solicitante
* Las muestras cumplen con la relación (altura / diámetro), por lo que no fue necesaria la corrección de esfuerzo

Washington Rodriguez Olazabal
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MÉTODO DE PRUEBA ESTÁNDAR PARA LA RESISTENCIA A LA COMPRESIÓN DE PROBETAS CILÍNDRICAS DE HORMIGÓN

ASTM C39/C39M-20

PROYECTO : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

REGISTRO N°: **LH22-CERT-127**

SOLICITANTE : BACH. JOSUÉ LINO CÁCERES SONCCO

UBICACIÓN DE PROYECTO : DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO

FECHA DE EMISIÓN : 11/05/2022

REALIZADO POR : Laboratorio LH

FECHA DE ENSAYO : 11/05/2022

TURNO : Diurno

Tipo de muestra : Concreto endurecido

Presentación : Especímenes cilíndricos 6" x 12"

F'c de diseño : f'c = 280 kg/cm2

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	EDAD (días)	DIÁMETRO (mm)	LONGITUD (mm)	ÁREA (mm^2)	TIPO DE FALLA	FUERZA MÁXIMA (KN)	ESFUERZO Mpa	ESFUERZO kg/cm2
PATRON + 2.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	28	151.1	308.5	17931.6	5	516.94	28.83	293.97
PATRON + 2.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	28	152.6	308.5	18289.4	3	524.10	28.66	292.21
PATRON + 2.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	28	152.5	308.0	18265.4	3	524.96	28.74	293.07
								DESVIACION ESTANDAR :	**0.09**	**0.88**
								PROMEDIO (Mpa) :	**28.74**	**293.08**
								% RESISTENCIA PROMEDIO :	**104.67**	**104.67**
								COEFICIENTE DE VARIACION (%) :	**0.30**	**0.30**
								RANGO DE VARIACION :	**0.60**	**0.60**

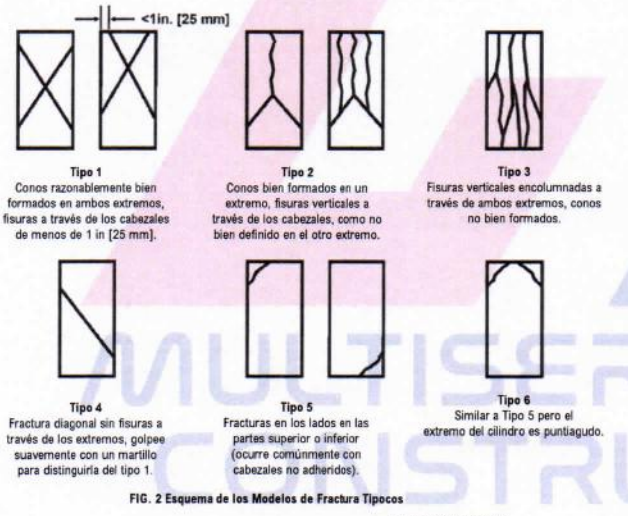

FIG. 2 Esquema de los Modelos de Fractura Tipocos

Fuente: ASTM C39

Si la relación entre la longitud y el diámetro de la muestra es 1,75 o menos, corrija el resultado obtenido en ESFUERZO (Mpa) multiplicando por el factor de corrección apropiado que se muestra en la siguiente tabla:

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

Utilice la interpolación para determinar los factores de corrección para L / D valores entre los dados en la tabla.

Fuente: ASTM C39

	Coeficiente de Variacion	Rango Aceptable de Resistencias de cilindros individuales: 2 Cilindros	3 Cilindros
6 a 12 Pulgadas [150 a 300 mm]			
Condiciones de Laboratorio	2.4 %	6.6 %	7.8 %
Condiciones de Campo	2.9 %	8.0 %	9.5 %
4 a 8 Pulgadas [100 a 200 mm]			
Condiciones de Laboratorio	3.2 %	9.0 %	10.6 %

Fuente: ASTM C39

OBSERVACIONES:

* Muestras elaboradas y curadas por el solicitante
* Las muestras cumplen con la relación (altura / diámetro), por lo que no fue necesaria la corrección de esfuerzo

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MÉTODO DE PRUEBA ESTÁNDAR PARA LA RESISTENCIA A LA COMPRESIÓN DE PROBETAS CILÍNDRICAS DE HORMIGÓN

ASTM C39/C39M-20

PROYECTO	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022	**REGISTRO N°:**	**LH22-CERT-127**
SOLICITANTE	: BACH. JOSUÉ LINO CÁCERES SONCCO	**REALIZADO POR :**	Laboratorio LH
UBICACIÓN DE PROYECTO	: DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO	**FECHA DE ENSAYO :**	11/05/2022
FECHA DE EMISIÓN	: 11/05/2022	**TURNO :**	Diurno

Tipo de muestra : Concreto endurecido
Presentación : Especímenes cilíndricos 6" x 12"
F'c de diseño : f'c = 280 kg/cm2

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	EDAD (días)	DIÁMETRO (mm)	LONGITUD (mm)	ÁREA (mm^2)	TIPO DE FALLA	FUERZA MÁXIMA (KN)	ESFUERZO Mpa	ESFUERZO kg/cm2
PATRON + 3.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	28	152.0	302.0	18145.8	5	525.41	28.95	295.26
PATRON + 3.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	28	152.6	305.0	18289.4	5	532.23	29.10	296.74
PATRON + 3.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	28	152.4	308.0	18241.5	5	529.78	29.04	296.15
								DESVIACION ESTANDAR :	**0.07**	**0.75**
								PROMEDIO (Mpa) :	**29.03**	**296.05**
								% RESISTENCIA PROMEDIO :	**105.73**	**105.73**
								COEFICIENTE DE VARIACION (%) :	**0.25**	**0.25**
								RANGO DE VARIACION :	**0.50**	**0.50**

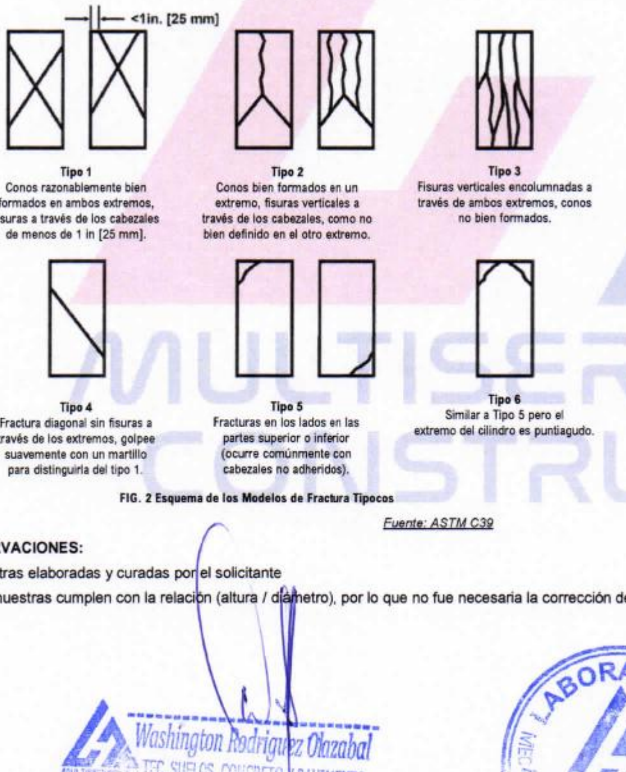

FIG. 2 Esquema de los Modelos de Fractura Tipocos

Fuente: ASTM C39

Si la relación entre la longitud y el diámetro de la muestra es 1,75 o menos, corrija el resultado obtenido en ESFUERZO (Mpa) multiplicando por el factor de corrección apropiado que se muestra en la siguiente tabla:

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

Utilice la interpolación para determinar los factores de corrección para L / D valores entre los dados en la tabla.

Fuente: ASTM C39

	Coeficiente de Variacion	Rango Aceptable de Resistencias de cilindros individuales 2 Cilindros	3 Cilindros
6 a 12 Pulgadas [150 a 300 mm]			
Condiciones de Laboratorio	2.4 %	6.6 %	7.8 %
Condiciones de Campo	2.9 %	8.0 %	9.5 %
4 a 8 Pulgadas [100 a 200 mm]			
Condiciones de Laboratorio	3.2 %	9.0 %	10.6 %

Fuente: ASTM C39

OBSERVACIONES:

* Muestras elaboradas y curadas por el solicitante
* Las muestras cumplen con la relación (altura / diámetro), por lo que no fue necesaria la corrección de esfuerzo

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MULTISERVICIOS Y CONSTRUCTORA LH
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Anexo No. 08: Resultados de resistencia a la flexión

CERTIFICADOS DE CALIDAD

(RESISTENCIA A FLEXIÓN)

MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH S.A.C.
Laboratorio: Jr. Honduras Urb. Taparachi 1 Sector Mza. B26 Lt. 7B - Juliaca - Puno
Oficinas Principales: Jr. Honduras Mza. B26 Lt. 7B - Cede Juliaca | Jr. Puno N° 633 - Cede Puno
Celular: +51 956 020220 | +51 988 080809 | E-Mail: constructoralh.sac@gmail.com
RUC: 20602295533

MÉTODO DE PRUEBA ESTÁNDAR PARA LA DETERMINACIÓN DEL MÓDULO DE ROTURA DEL HORMIGÓN - CONCRETO

ASTM C78/C78M-21

PROYECTO : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

REGISTRO N°: LH22-CERT-127

SOLICITANTE : BACH. JOSUÉ LINO CÁCERES SONCCO
UBICACIÓN DE PROYECTO : DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO
FECHA DE EMISIÓN : 11/05/2022

REALIZADO POR : Laboratorio LH
FECHA DE ENSAYO : 11/05/2022
TURNO : Diurno

Tipo de muestra : Concreto endurecido
Presentación : Especímenes cilíndricos 6" x 12"
F'c de diseño : f'c = 280 kg/cm2

Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	UBICACIÓN DE FALLA	EDAD	ANCHO (mm)	PROF. (mm)	LONGITUD (mm)	FUERZA MÁXIMA (N)	MODULO DE ROTURA (Mpa)	MODULO DE ROTURA (kg/cm2)
PATRON + 0.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	TERCIO CENTRAL	28	150	150	450	31616.77	4.22 MPa	42.99 kg/cm2
PATRON + 0.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	TERCIO CENTRAL	28	150	150	450	31502.47	4.20 MPa	42.83 kg/cm2
PATRON + 0.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	TERCIO CENTRAL	28	150	150	450	31554.99	4.21 MPa	42.90 kg/cm2

C78/C78M – 21

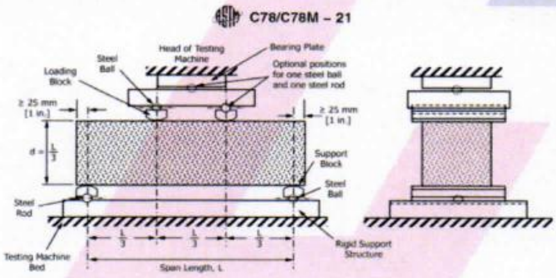

FIG. 1 Schematic of Flexural Testing Apparatus for Third-Point Loading Method

DESVIACION ESTANDAR :	0.01	0.08
PROMEDIO (Mpa) | (kg/cm2) :	4.21	42.91
% RESISTENCIA PROMEDIO :	102.16	102.16
COEFICIENTE DE VARIACION (%) :	0.18	0.18
RANGO DE VARIACION :	0.36	0.36

Fuente: ASTM C78

OBSERVACIONES:

* Muestras provistas e identificadas por el solicitante
* Las muestras cumplen con las dimensiones dadas en la norma de ensayo

Washington Rodriguez Olazabal
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LABORATORIO DE SUELOS, CONCRETO Y ASFALTO — MULTISERVICIOS Y CONSTRUCTORA

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MÉTODO DE PRUEBA ESTÁNDAR PARA LA DETERMINACIÓN DEL MÓDULO DE ROTURA DEL HORMIGÓN - CONCRETO

ASTM C78/C78M-21

PROYECTO	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN	**REGISTRO N°:**	**LH22-CERT-127**
SOLICITANTE	: BACH. JOSUÉ LINO CÁCERES SONCCO	**REALIZADO POR :**	Laboratorio LH
UBICACIÓN DE PROYECTO	: DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO	**FECHA DE ENSAYO :**	11/05/2022
FECHA DE EMISIÓN	: 11/05/2022	**TURNO :**	Diurno

Tipo de muestra	: Concreto endurecido
Presentación	: Especímenes cilíndricos 6" x 12"
F'c de diseño	: f'c = 280 kg/cm2

Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	UBICACIÓN DE FALLA	EDAD	ANCHO (mm)	PROF. (mm)	LONGITUD (mm)	FUERZA MÁXIMA (N)	MODULO DE ROTURA (Mpa)	MODULO DE ROTURA (kg/cm2)
PATRON + 1.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	TERCIO CENTRAL	28	150	150	450	32120.29	4.28 MPa	43.67 kg/cm2
PATRON + 1.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	TERCIO CENTRAL	28	150	150	450	31956.57	4.26 MPa	43.45 kg/cm2
PATRON + 1.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	TERCIO CENTRAL	28	150	150	450	32073.95	4.28 MPa	43.61 kg/cm2

DESVIACION ESTANDAR :	**0.01**	**0.11**
PROMEDIO (Mpa) | (kg/cm2) :	**4.27**	**43.58**
% RESISTENCIA PROMEDIO :	**103.75**	**103.75**
COEFICIENTE DE VARIACION (%) :	**0.26**	**0.26**
RANGO DE VARIACION :	**0.51**	**0.51**

C78/C78M – 21

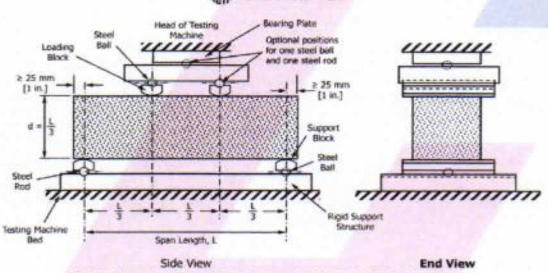

FIG. 1 Schematic of Flexural Testing Apparatus for Third-Point Loading Method

Fuente: ASTM C78

OBSERVACIONES:

* Muestras provistas e identificadas por el solicitante
* Las muestras cumplen con las dimensiones dadas en la norma de ensayo

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MULTISERVICIOS Y CONSTRUCTORA LH S.A.C.

MULTISERVICIOS Y CONSTRUCTORA

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Oficinas Principales: Jr. Honduras Mza. B26 Lt. 7B - Cede Juliaca | Jr. Puno N° 633 - Cede Puno
Celular: +51 956 020220 | +51 988 080809 | E-Mail: constructoralh.sac@gmail.com
RUC: 20602295533

MÉTODO DE PRUEBA ESTÁNDAR PARA LA DETERMINACIÓN DEL MÓDULO DE ROTURA DEL HORMIGÓN - CONCRETO

ASTM C78/C78M-21

PROYECTO	: EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN	**REGISTRO N°:**	**LH22-CERT-127**
SOLICITANTE	: BACH. JOSUÉ LINO CÁCERES SONCCO	**REALIZADO POR :**	Laboratorio LH
UBICACIÓN DE PROYECTO	: DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO	**FECHA DE ENSAYO :**	11/05/2022
FECHA DE EMISIÓN	: 11/05/2022	**TURNO :**	Diurno

Tipo de muestra	: Concreto endurecido
Presentación	: Especímenes cilíndricos 6" x 12"
F'c de diseño	: f'c = 280 kg/cm2

Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	UBICACIÓN DE FALLA	EDAD	ANCHO (mm)	PROF. (mm)	LONGITUD (mm)	FUERZA MÁXIMA (N)	MODULO DE ROTURA (Mpa)	MODULO DE ROTURA (kg/cm2)
PATRON + 2.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	TERCIO CENTRAL	28	150	150	450	32577.47	4.34 MPa	44.29 kg/cm2
PATRON + 2.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	TERCIO CENTRAL	28	150	150	450	32401.39	4.32 MPa	44.05 kg/cm2
PATRON + 2.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	TERCIO CENTRAL	28	150	150	450	32534.23	4.34 MPa	44.23 kg/cm2

C78/C78M – 21

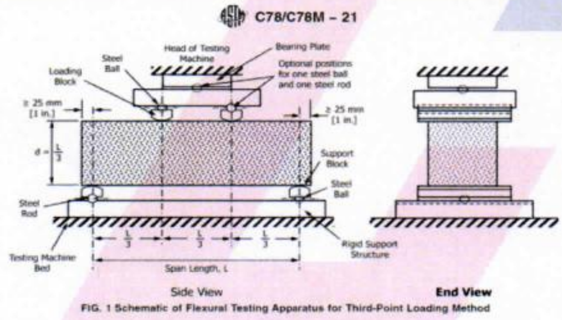

FIG. 1 Schematic of Flexural Testing Apparatus for Third-Point Loading Method

DESVIACION ESTANDAR :	**0.01**	**0.12**
PROMEDIO (Mpa) | (kg/cm2) :	**4.33**	**44.19**
% RESISTENCIA PROMEDIO :	**105.22**	**105.22**
COEFICIENTE DE VARIACION (%) :	**0.28**	**0.28**
RANGO DE VARIACION :	**0.54**	**0.54**

Fuente: ASTM C78

OBSERVACIONES:

* Muestras provistas e identificadas por el solicitante
* Las muestras cumplen con las dimensiones dadas en la norma de ensayo

Washington Rodriguez Olazabal
TEC. SUELOS, CONCRETO Y PAVIMENTO
DNI. 02436007

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MÉTODO DE PRUEBA ESTÁNDAR PARA LA DETERMINACIÓN DEL MÓDULO DE ROTURA DEL HORMIGÓN - CONCRETO

ASTM C78/C78M-21

PROYECTO : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN

REGISTRO N°: LH22-CERT-127

SOLICITANTE : BACH. JOSUÉ LINO CÁCERES SONCCO

REALIZADO POR : Laboratorio LH

UBICACIÓN DE PROYECTO : DISTRITO: JULIACA, PROVINCIA: SAN ROMAN, DEPARTAMENTO: PUNO

FECHA DE ENSAYO : 11/05/2022

FECHA DE EMISIÓN : 11/05/2022

TURNO : Diurno

Tipo de muestra : Concreto endurecido
Presentación : Especímenes cilíndricos 6" x 12"
F'c de diseño : f'c = 280 kg/cm2

Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

IDENTIFICACIÓN	FECHA DE VACIADO	FECHA DE ROTURA	UBICACIÓN DE FALLA	EDAD	ANCHO (mm)	PROF. (mm)	LONGITUD (mm)	FUERZA MÁXIMA (N)	MODULO DE ROTURA (Mpa)	MODULO DE ROTURA (kg/cm2)
PATRON + 3.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	TERCIO CENTRAL	28	150	150	450	33047.01	4.41 MPa	44.93 kg/cm2
PATRON + 3.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	TERCIO CENTRAL	28	150	150	450	32975.96	4.40 MPa	44.84 kg/cm2
PATRON + 3.0% MUCÍLAGO DE CACTACEAS	13/04/2022	11/05/2022	TERCIO CENTRAL	28	150	150	450	33025.39	4.40 MPa	44.90 kg/cm2

DESVIACION ESTANDAR :	0.00	0.05
PROMEDIO (Mpa) | (kg/cm2) :	4.40	44.89
% RESISTENCIA PROMEDIO :	106.88	106.88
COEFICIENTE DE VARIACION (%) :	0.11	0.11
RANGO DE VARIACION :	0.22	0.22

C78/C78M – 21

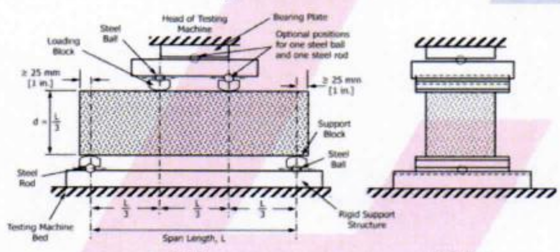


FIG. 1 Schematic of Flexural Testing Apparatus for Third-Point Loading Method

Fuente: ASTM C78

OBSERVACIONES:

* Muestras provistas e identificadas por el solicitante
* Las muestras cumplen con las dimensiones dadas en la norma de ensayo

Washington Rodriguez Olazabal
TEC. SUELOS, CONCRETO Y PAVIMENTO
DNI. 02436007

LABORATORIO DE SUELOS, CONCRETO Y ASFALTO — MULTISERVICIOS Y CONSTRUCTORA

MULTISERVICIOS Y CONSTRUCTORA LH
Juan Manuel Frizancho Aguirre
CIP. 45130
JEFE DE LABORATORIO DE SUELOS Y PAVIMENTOS

PROHIBIDA LA REPRODUCCIÓN TOTAL O PARCIAL DE ESTE DOCUMENTO SIN AUTORIZACIÓN ESCRITA DEL LABORATORIO MULTISERVICIOS Y CONSTRUCTORA LH S.A.C., ASÍ MISMO CARECE DE INVALIDES SIN EL SELLO Y FIRMA.

Anexo No. 09: Resultados de permeabilidad de concreto

LABORATORIO DE SUELOS Y CONCRETO

Contratistas Generales GeoCONTROL TOTAL E.I.R.L.
Ingeniería - Construcción - Control de Calidad

CONTROL Y ASEGURAMIENTO DE CALIDAD EN OBRAS CIVILES

RUC: 20601612616

CODIGO DE INFORME
GCT-EC-017

INFORME DE ENSAYO

PROFUNDIDAD DE PENETRACIÓN DE AGUA BAJO PRESIÓN

NORMA: UNE 12390-8

PROYECTO : EFECTOS DE LA ADICION DE ADITIVOS NATURALES MUCILAGO DE CACTACEAE EN CONCRETO HIDRAULICO PARA SU APLICACION EN PAVIMENTOS RIGIDOS EN REGION PUNO 2022

UBICACIÓN: PUNO - SAN ROMAN - JULIACA

SOLICITA : BACH. JOSUÉ LINO CÁCERES SONCCO

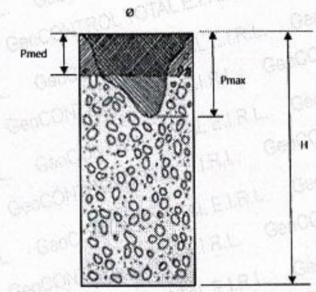
F. SOLICITUD : 2023-12-17

F. EJECUCION: 2023-12-27 (entrega de certificado)

ENSAYADO EN: LABORATORIO GEOCONTROL TOTAL E.I.R.L.

Nº	ENSAYO								RESULTADOS	
	PROBETA		FECHA DEL ENSAYO		ALTURA H	DIAMETRO ø	MASA SECA	MASA FINAL	PROFUNDIDAD DE PENETRACION MEDIA	PROFUNDIDAD DE PENETRACION MÁXIMA
	ELEMENTO	CODIGO	INICIO	TERMINO	(cm)	(cm)	(kg)	(kg)	(mm)	(mm)
1	MUESTRA PATRON	---	2023-12-18	2023-12-21	30.08	15.22	11.612	11.745	40.30	80.60
2	MUESTRA PATRON	---	2023-12-18	2023-12-21	30.04	15.17	11.416	11.537	40.10	80.20
3	MUESTRA PATRON	---	2023-12-18	2023-12-21	30.10	15.24	11.540	11.675	39.80	79.60
4	MUESTRA PATRON + 1% MUCÍLAGO DE CACTACEAS	---	2023-12-18	2023-12-21	30.02	15.09	11.270	11.384	29.45	58.90
5	MUESTRA PATRON + 1% MUCÍLAGO DE CACTACEAS	---	2023-12-18	2023-12-21	30.13	15.09	11.316	11.412	30.15	60.30
6	MUESTRA PATRON + 1% MUCÍLAGO DE CACTACEAS	---	2023-12-18	2023-12-21	30.12	15.12	11.346	11.451	30.05	60.10
7	MUESTRA PATRON + 2% MUCÍLAGO DE CACTACEAS	---	2023-12-22	2023-12-25	30.26	15.20	11.256	11.337	25.85	51.70
8	MUESTRA PATRON + 2% MUCÍLAGO DE CACTACEAS	---	2023-12-22	2023-12-25	30.05	15.17	11.106	11.220	28.20	56.40
9	MUESTRA PATRON + 2% MUCÍLAGO DE CACTACEAS	---	2023-12-22	2023-12-25	30.08	15.21	11.190	11.274	33.10	66.20
10	MUESTRA PATRON + 3% MUCÍLAGO DE CACTACEAS	---	2023-12-22	2023-12-25	30.11	15.21	11.031	11.129	29.80	59.60
11	MUESTRA PATRON + 3% MUCÍLAGO DE CACTACEAS	---	2023-12-22	2023-12-25	30.11	15.21	11.088	11.189	26.05	52.10
12	MUESTRA PATRON + 3% MUCÍLAGO DE CACTACEAS	---	2023-12-22	2023-12-25	30.13	15.06	11.024	11.138	27.10	54.20

EVALUACIÓN DE LA PENETRACIÓN			
RESISTENCIA	EDAD	SUPERFICIE	TIEMPO DE PRUEBA
280 Kg/cm2	28 DIAS	RUGOSA	72 Horas



OBSERVACIONES

DEFECTOS DE LOS ESPECIMENES:	NO	TAMAÑO DE PROBETAS: 15x30 cm.

1. los resultados de los ensayos solo corresponden a las muestras proporcionadas por el solicitante.
2. El espesor del especimen no será menor a 100 mm
3. La probeta fue secada antes del ensayo a 50±5°C durante 24 horas.
4. Las muestras fueron ensayadas en condiciones del laboratorio (humedad y temperatura).
5. El diametro y la altura es medida promedio en base a dos lecturas.
6. ---
7. ---

FORMA :	CILINDRICA
PRESIÓN :	500±50 Kpa / 72±2 horas
AGUA :	DE RED
TEMPERATURA AMB:	23 °C
HUMEDAD AMB:	36.0%
PESADO :	SI
TOLERANCIA DE PRESIÓN :	0 %

PROBETA (Solo en muestras cubicas)

GEOCONTROL TOTAL E.I.R.L.

LABORATORIO DE SUELOS CONCRETO Y ASFALTO - GEOCONTROL TOTAL E.I.R.L.

Ing. Raúl Miranda Quintanilla
CIP: 131480

Los resultados reflejados en este informe solo están relacionados a la muestra ensayada.
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El laboratorio no se hace responsable del mal uso ni la incorrecta interpretación de los resultados aquí declarados.

Dirección: Av. Circunvalación N° 1728 - Juliaca (Ref. ex ovalo salida cusco)
Telefonos: 051-328588 / 951 010447 / 951 671568
Correos: informes@geocontroltotal.com / geocontroltotal@gmail.com
www.geocontroltotal.com.pe

Anexo No. 10: Calculo de espesor de Pavimento Rígido

DISEÑO DE PAVIMENTO RÍGIDO CONCRETO PATRON

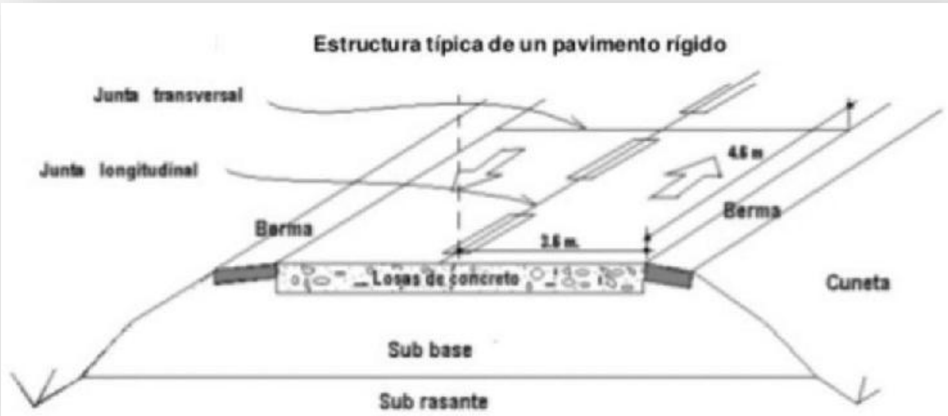
Modificar datos: (amarillo) Cálculos automáticos (verde) Resultados (turquesa)

Cargas de tráfico vehicular impuestos al pavimento	ESAL(W18)	1 143 334
CBR de la subrasante (%)	CBR =	7.2 %
Resistencia del concreto (Kg/cm2)	(F´c)	285.26
Módulo elástico del concreto (PSI) $E = 57000x(f'c)^{0.5}$; $(fc\ en\ PSI)$	Ec	3630742.758
Resistencia media del concreto a flexo tracción a los 28 días(Kg/cm2) $M_r = a\sqrt{f'c}$	Mr	42.91
Modulo de reacción de la subrasante (Mpa/m)	Ko	47.00
CBR mínimo de la subbase (%) TRUE	CBR(subB.) =	40.0 %
CBR mínimo de la subbase - definido (%)	CBR DEF.	50.0 %
Modulo de reacción de la subbase granular (Mpa/m)	K1(subB.) =	140.00
Espesor de la subbase granular (cm) recomendado por la MTC	h=	40.00
Coeficiente de reacción combinado (Mpa) $K_c = \left(1 + \left(\frac{h}{38}\right)^2 x \left(\frac{K_1}{K_0}\right)^{\frac{2}{3}}\right)^{0.5} x\ K_0$	Kc	85.30
Tipo de tráfico	Tipo:	TP5
Indice de serviciabilidad Inicial según rango de tráfico	Pi	4.3
Indice de serviciabilidad final según rango de tráfico	Pt	2.5
Diferencial de serviciabilidad según rango de tráfico	Δ PSI	1.8
Desviación estandar combinado	So	0.35
Nivel de confiabilidad	conf.	85.0 %
Coeficiente estadústico de desviación estandar normal	ZR	-1.036
Condiciones de drenaje	cd	1.0
Coeficiente de transmisión de carga en las juntas Concreto hidráulico sin pasadores	J	3.8

$$log_{10}(W_{18}) = Z_R S_O + 7.35\ log_{10}(D + 25.4) - 10.39 + \frac{log_{10}\left(\frac{\Delta PSI}{4.5 - 1.5}\right)}{1 + \frac{1.25x10^{19}}{(D + 25.4)^{8.46}}} + (4.22 - 0.32P_t)xlog_{10}\left(\frac{M_r C_{dx}(0.09D^{0.75} - 1.132)}{1.51xJ\left(0.09D^{0.75} - \frac{7.38}{(E_c/k)^{0.25}}\right)}\right)$$

Espesor de pavimento de concreto en milímetros (mm)	Calcular D	D= 189.53

D-0	D-1
19 cm	40 cm
Capa superficial (Losa de concreto)	SubBase Granular



DISEÑO DE PAVIMENTO RÍGIDO: CONCRETO PATRON+1%MC

Modificar datos:	Cálculos automáticos	Resultados

Cargas de tráfico vehicular impuestos al pavimento	ESAL(W18)	1 143 334
CBR de la subrasante (%)	CBR =	7.2 %
Resistencia del concreto (Kg/cm2)	(F´c)	288.57
Módulo elástico del concreto (PSI) $E = 57000x(f'c)^{0.5}$; $(fc\ en\ PSI)$	Ec	3651746.575
Resistencia media del concreto a flexo tracción a los 28 días(Kg/cm2) $M_r = a\sqrt{f'c}$	Mr	43.57
Modulo de reacción de la subrasante (Mpa/m)	Ko	47.00
CBR mínimo de la subbase (%) TRUE	CBR(subB.) =	40.0 %
CBR mínimo de la subbase - definido (%)	CBR DEF.	50.0 %
Modulo de reacción de la subbase granular (Mpa/m)	K1(subB.) =	140.00
Espesor de la subbase granular (cm) recomendado por la MTC	h=	40.00
Coeficiente de reacción combinado (Mpa) $K_c = \left(1 + \left(\frac{h}{38}\right)^2 x \left(\frac{K_1}{K_0}\right)^{\frac{2}{3}}\right)^{0.5} x\ K_0$	Kc	85.30
Tipo de tráfico	Tipo:	TP5
Indice de serviciabilidad Inicial según rango de tráfico	Pi	4.3
Indice de serviciabilidad final según rango de tráfico	Pt	2.5
Diferencial de serviciabilidad según rango de tráfico	Δ PSI	1.8
Desviación estandar combinado	So	0.35
Nivel de confiabilidad	conf.	85.0 %
Coeficiente estadústico de desviación estandar normal	ZR	-1.036
Condiciones de drenaje	cd	1.0
Coeficiente de transmisión de carga en las juntas Concreto hidráulico sin pasadores	J	3.8

$$log_{10}(W_{18}) = Z_R S_O + 7.35\, log_{10}(D + 25.4) - 10.39 + \frac{log_{10}\left(\frac{\Delta PSI}{4.5 - 1.5}\right)}{1 + \frac{1.25x10^{19}}{(D + 25.4)^{8.46}}} + (4.22 - 0.32P_t)x log_{10}\left(\frac{M_r C_{dx}(0.09D^{0.75} - 1.132)}{1.51xJ\left(0.09D^{0.75} - \frac{7.38}{(E_c/k)^{0.25}}\right)}\right)$$

Espesor de pavimento de concreto en milímetros (mm) Calcular D	D=	187.64

D-0	D-1
19 cm	**40 cm**
Capa superficial (Losa de concreto)	SubBase Granular

DISEÑO DE PAVIMENTO RÍGIDO: CONCRETO PATRON+2%MC

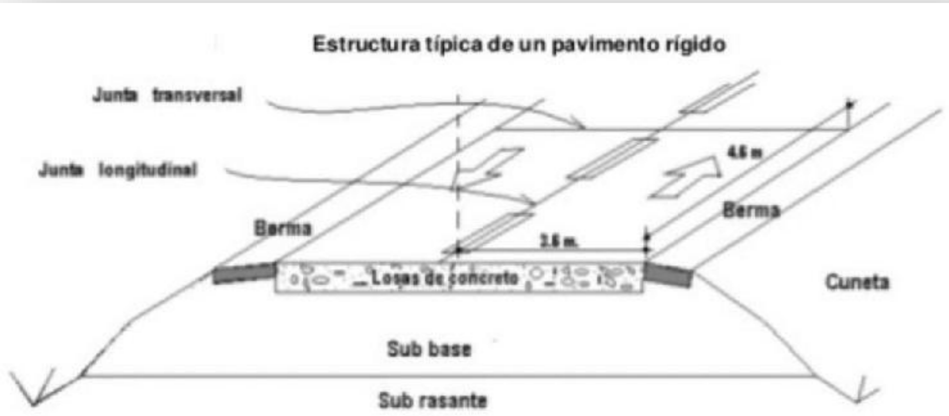
Modificar datos:	Cálculos automáticos	Resultados

Cargas de tráfico vehicular impuestos al pavimento	ESAL(W18)	1 143 334
CBR de la subrasante (%)	CBR =	7.2 %
Resistencia del concreto (Kg/cm2)	(F´c)	293.08
Módulo elástico del concreto (PSI) $E = 57000x(f'c)^{0.5}$; $(fc\ en\ PSI)$	Ec	3680172.132
Resistencia media del concreto a flexo tracción a los 28 días(Kg/cm2) $M_r = a\sqrt{f'c}$	Mr	44.19
Modulo de reacción de la subrasante (Mpa/m)	Ko	47.00
CBR mínimo de la subbase (%) TRUE	CBR(subB.) =	40.0 %
CBR mínimo de la subbase - definido (%)	CBR DEF.	50.0 %
Modulo de reacción de la subbase granular (Mpa/m)	K1(subB.) =	140.00
Espesor de la subbase granular (cm) recomendado por la MTC	h=	40.00
Coeficiente de reacción combinado (Mpa) $K_c = \left(1 + \left(\frac{h}{38}\right)^2 x \left(\frac{K_1}{K_0}\right)^{\frac{2}{3}}\right)^{0.5} x\ K_0$	Kc	85.30
Tipo de tráfico	Tipo:	TP5
Indice de serviciabilidad Inicial según rango de tráfico	Pi	4.3
Indice de serviciabilidad final según rango de tráfico	Pt	2.5
Diferencial de serviciabilidad según rango de tráfico	Δ PSI	1.8
Desviación estandar combinado	So	0.35
Nivel de confiabilidad	conf.	85.0 %
Coeficiente estadústico de desviación estandar normal	ZR	-1.036
Condiciones de drenaje	cd	1.0
Coeficiente de transmisión de carga en las juntas Concreto hidráulico sin pasadores	J	3.8

$$log_{10}(W_{18}) = Z_R S_O + 7.35\ log_{10}(D + 25.4) - 10.39 + \frac{log_{10}\left(\frac{\Delta PSI}{4.5 - 1.5}\right)}{1 + \frac{1.25x10^{19}}{(D + 25.4)^{8.46}}} + (4.22 - 0.32P_t)xlog_{10}\left(\frac{M_r C_{dx}(0.09D^{0.75} - 1.132)}{1.51xJ\left(0.09D^{0.75} - \frac{7.38}{(E_c/k)^{0.25}}\right)}\right)$$

Espesor de pavimento de concreto en milímetros (mm) Calcular D	D=	186.09

D-0	D-1
19 cm	40 cm
Capa superficial (Losa de concreto)	SubBase Granular



DISEÑO DE PAVIMENTO RÍGIDO: CONCRETO PATRON+3%MC

Modificar datos: Cálculos automáticos Resultados

Cargas de tráfico vehicular impuestos al pavimento		ESAL(W18)	1 143 334
CBR de la subrasante (%)		CBR =	7.2 %
Resistencia del concreto (Kg/cm2)		(F´c)	292.82
Módulo elástico del concreto (PSI)	$E = 57000x(f'c)^{0.5}$; $(fc\ en\ PSI)$	Ec	3678539.374
Resistencia media del concreto a flexo tracción a los 28 días(Kg/cm2)	$M_r = a\sqrt{f'c}$	Mr	44.89
Modulo de reacción de la subrasante (Mpa/m)		Ko	47.00
CBR mínimo de la subbase (%)	TRUE	CBR(subB.) =	40.0 %
CBR mínimo de la subbase - definido (%)		CBR DEF.	50.0 %
Modulo de reacción de la subbase granular (Mpa/m)		K1(subB.) =	140.00
Espesor de la subbase granular (cm) recomendado por la MTC		h=	40.00
Coeficiente de reacción combinado (Mpa)	$K_c = \left(1+\left(\frac{h}{38}\right)^2 x\left(\frac{K_1}{K_0}\right)^{\frac{2}{3}}\right)^{0.5} x\ K_0$	Kc	85.30
Tipo de tráfico		Tipo:	TP5
Indice de serviciabilidad Inicial según rango de tráfico		Pi	4.3
Indice de serviciabilidad final según rango de tráfico		Pt	2.5
Diferencial de serviciabilidad según rango de tráfico		Δ PSI	1.8
Desviación estandar combinado		So	0.35
Nivel de confiabilidad		conf.	85.0 %
Coeficiente estadústico de desviación estandar normal		ZR	-1.036
Condiciones de drenaje		cd	1.0
Coeficiente de transmisión de carga en las juntas Concreto hidráulico sin pasadores		J	3.8

$$\log_{10}(W_{18}) = Z_R S_O + 7.35\,\log_{10}(D+25.4) - 10.39 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.5-1.5}\right)}{1+\frac{1.25x10^{19}}{(D+25.4)^{8.46}}} + (4.22-0.32P_t)x\log_{10}\left(\frac{M_r C_{dx}(0.09D^{0.75}-1.132)}{1.51xJ\left(0.09D^{0.75}-\frac{7.38}{(E_c/k)^{0.25}}\right)}\right)$$

Espesor de pavimento de concreto en milímetros (mm)	Calcular D	D=	184.10

D-0	D-1
18 cm	**40 cm**
Capa superficial (Losa de concreto)	SubBase Granular

Anexo No. 11: Normativas ASTM

This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

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INTERNATIONAL

Designation: C136/C136M – 19

Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates[1]

This standard is issued under the fixed designation C136/C136M; 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 U.S. Department of Defense.

1. Scope*

1.1 This test method covers the determination of the particle size distribution of fine and coarse aggregates by sieving.

1.2 Some specifications for aggregates which reference this test method contain grading requirements including both coarse and fine fractions. Instructions are included for sieve analysis of such aggregates.

1.3 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. 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.

NOTE 1—Sieve size is identified by its standard designation in Specification E11. The alternative designation given in parentheses is for information only and does not represent a different standard sieve size. Specification E11 cites the following with respect to SI units versus inch-pound units as standard. "The values stated in SI units shall be considered standard for the dimensions of the sieve cloth openings and the wire diameters used in the sieve cloth. The values stated in inch-pound units shall be considered standard with regard to the sieve frames, pans," and covers.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C117 Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing

C125 Terminology Relating to Concrete and Concrete Aggregates

C637 Specification for Aggregates for Radiation-Shielding Concrete

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

C702 Practice for Reducing Samples of Aggregate to Testing Size

D75 Practice for Sampling Aggregates

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2 *AASHTO Standard:*

AASHTO No. T 27 Sieve Analysis of Fine and Coarse Aggregates[3]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this standard, refer to Terminology C125.

4. Summary of Test Method

4.1 A sample of dry aggregate of known mass is separated through a series of sieves of progressively smaller openings for determination of particle size distribution.

5. Significance and Use

5.1 This test method is used primarily to determine the grading of materials proposed for use as aggregates or being used as aggregates. The results are used to determine compliance of the particle size distribution with applicable specification requirements and to provide necessary data for control of

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.20 on Aggregates.

Current edition approved Dec. 1, 2019. Published January 2020. Originally approved in 1938. Last previous edition approved in 2014 as C136 – 14. DOI: 10.1520/C0136_C0136M-19.

[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.

[3] Available from American Association of State Highway and Transportation Officials, 444 North Capitol St. N.W., Suite 225, Washington, DC 20001.

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

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the production of various aggregate products and mixtures containing aggregates. The data may also be useful in developing relationships concerning porosity and packing.

5.2 Accurate determination of material finer than the 75-µm (No. 200) sieve cannot be achieved by use of this test method alone. Use Test Method C117 for determination of material finer than the 75-µm (No. 200) sieve by washing.

5.3 Refer to methods of sampling and testing in Specification C637 for heavyweight aggregates.

6. Apparatus

6.1 *Balances*—Balances or scales used in testing fine and coarse aggregate shall have readability and accuracy as follows:

6.1.1 For fine aggregate, readable to 0.1 g and accurate to 0.1 g or 0.1 % of the test load, whichever is greater, at any point within the range of use.

6.1.2 For coarse aggregate, or mixtures of fine and coarse aggregate, readable and accurate to 0.5 g or 0.1 % of the test load, whichever is greater, at any point within the range of use.

6.2 *Sieves*—The sieve cloth shall be mounted on substantial frames constructed in a manner that will prevent loss of material during sieving. The sieve cloth and standard sieve frames shall conform to the requirements of Specification E11. Nonstandard sieve frames shall conform to the requirements of Specification E11 as applicable.

NOTE 2—It is recommended that sieves mounted in frames larger than standard 203.2-mm [8 in.] diameter be used for testing coarse aggregate to reduce the possibility of overloading the sieves. See 8.3.

6.3 *Mechanical Sieve Shaker*—A mechanical sieving device, if used, shall create motion of the sieves to cause the particles to bounce, tumble, or otherwise turn so as to present different orientations to the sieving surface. The sieving action shall be such that the criterion for adequacy of sieving described in 8.4 is met in a reasonable time period.

NOTE 3—Use of a mechanical sieve shaker is recommended when the size of the sample is 20 kg or greater, and may be used for smaller samples, including fine aggregate. Excessive time (more than approximately 10 min) to achieve adequate sieving may result in degradation of the sample. The same mechanical sieve shaker may not be practical for all sizes of samples, since the large sieving area needed for practical sieving of a large nominal size coarse aggregate very likely could result in loss of a portion of the sample if used for a small sample of coarse aggregate or fine aggregate.

6.4 *Oven*—An oven of appropriate size capable of maintaining a uniform temperature of 110 ± 5 °C [230 ± 10 °F].

7. Sampling

7.1 Sample the aggregate in accordance with Practice D75. The size of the field sample shall be the quantity shown in Practice D75 or four times the quantity required in 7.4 and 7.5 (except as modified in 7.6), whichever is greater.

7.2 Thoroughly mix the sample and reduce it to an amount suitable for testing using the applicable procedures described in Practice C702. The sample for test shall be approximately the quantity desired when dry and shall be the end result of the reduction. Reduction to an exact predetermined quantity shall not be permitted.

NOTE 4—Where sieve analysis, including determination of material finer than the 75-µm sieve, is the only testing proposed, the size of the sample may be reduced in the field to avoid shipping excessive quantities of extra material to the laboratory.

7.3 *Fine Aggregate*—The size of the test sample, after drying, shall be 300 g minimum.

7.4 *Coarse Aggregate*—The size of the test sample of coarse aggregate shall conform with the following:

Nominal Maximum Size, Square Openings, mm (in.)	Test Sample Size, min, kg [lb]
9.5 (⅜)	1 [2]
12.5 (½)	2 [4]
19.0 (¾)	5 [11]
25.0 (1)	10 [22]
37.5 (1½)	15 [33]
50 (2)	20 [44]
63 (2½)	35 [77]
75 (3)	60 [130]
90 (3½)	100 [220]
100 (4)	150 [330]
125 (5)	300 [660]

7.5 *Coarse and Fine Aggregate Mixtures*—The size of the test sample of coarse and fine aggregate mixtures shall be the same as for coarse aggregate in 7.4.

7.6 *Samples of Large Size Coarse Aggregate*—The size of sample required for aggregate with 50-mm [2-in.] nominal maximum size or larger is such as to preclude convenient sample reduction and testing as a unit except with large mechanical splitters and sieve shakers. As an option when such equipment is not available, instead of combining and mixing sample increments and then reducing the field sample to testing size, conduct the sieve analysis on a number of approximately equal sample increments such that the total mass tested conforms to the requirement of 7.4.

7.7 In the event that the amount of material finer than the 75-µm (No. 200) sieve is to be determined by Test Method C117, proceed as follows:

7.7.1 For aggregates with a nominal maximum size of 12.5 mm [½ in.] or less, use the same test sample for testing by Test Method C117 and this test method. First test the sample in accordance with Test Method C117 through the final drying operation, then dry sieve the sample as stipulated in 8.2 – 8.7 of this test method.

7.7.2 For aggregates with a nominal maximum size greater than 12.5 mm [½ in.], use a single test sample as described in 7.7.1, or optionally use separate test samples for Test Method C117 and this test method.

7.7.3 Where the specifications require determination of the total amount of material finer than the 75-µm sieve by washing and dry sieving, use the procedure described in 7.7.1.

8. Procedure

8.1 Dry the sample to constant mass at a temperature of 110 ± 5 °C [230 ± 10 °F].

NOTE 5—For control purposes, particularly where rapid results are desired, it is generally not necessary to dry coarse aggregate for the sieve analysis test. The results are little affected by the moisture content unless: (*1*) the nominal maximum size is smaller than about 12.5 mm (½ in.); (*2*) the coarse aggregate contains appreciable material finer than 4.75 mm (No. 4); or (*3*) the coarse aggregate is highly absorptive (a lightweight aggregate, for example). Also, samples may be dried at the higher

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temperatures associated with the use of hot plates without affecting results, provided steam escapes without generating pressures sufficient to fracture the particles, and temperatures are not so great as to cause chemical breakdown of the aggregate.

8.2 Select sieves with suitable openings to furnish the information required by the specifications covering the material to be tested. Use additional sieves as desired or necessary to provide other information, such as fineness modulus, or to regulate the amount of material on a sieve. Nest the sieves in order of decreasing size of opening from top to bottom and place the sample on the top sieve. Agitate the sieves by hand or by mechanical apparatus for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy or sieving described in 8.4.

8.3 Limit the quantity of material on a given sieve so that all particles have opportunity to reach sieve openings a number of times during the sieving operation. For sieves with openings smaller than 4.75-mm (No. 4), the quantity retained on any sieve at the completion of the sieving operation shall not exceed 7 kg/m^2 of sieving surface area (Note 6). For sieves with openings 4.75 mm (No. 4) and larger, the quantity retained in kg shall not exceed the product of 2.5 × (sieve opening, mm × (effective sieving area, m^2)). This quantity is shown in Table 1 for five sieve-frame dimensions in common use. In no case shall the quantity retained be so great as to cause permanent deformation of the sieve cloth.

8.3.1 Prevent an overload of material on an individual sieve by one of the following methods:

8.3.1.1 Insert an additional sieve with opening size intermediate between the sieve that may be overloaded and the sieve immediately above that sieve in the original set of sieves.

8.3.1.2 Split the sample into two or more portions, sieving each portion individually. Combine the masses of the several portions retained on a specific sieve before calculating the percentage of the sample on the sieve.

8.3.1.3 Use sieves having a larger frame size and providing greater sieving area.

NOTE 6—The 7 kg/m^2 amounts to 200 g for the usual 203-mm [8-in.] diameter sieve (with effective sieving surface diameter of 190.5 mm [7.5 in.].

8.4 Continue sieving for a sufficient period and in such manner that, after completion, not more than 1 % by mass of the material retained on any individual sieve will pass that sieve during 1 min of continuous hand sieving performed as follows: Hold the individual sieve, provided with a snug-fitting pan and cover, in a slightly inclined position in one hand. Strike the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turn the sieve about one sixth of a revolution at intervals of about 25 strokes. In determining sufficiency of sieving for sizes larger than the 4.75-mm (No. 4) sieve, limit the material on the sieve to a single layer of particles. If the size of the mounted testing sieves makes the described sieving motion impractical, use 203-mm [8 in.] diameter sieves to verify the sufficiency of sieving.

8.5 In the case of coarse and fine aggregate mixtures, refer to 8.3.1 to prevent overloading of individual sieves.

8.5.1 Optionally, reduce the portion finer than the 4.75-mm (No. 4) sieve using a mechanical splitter according to Practice C702. If this procedure is followed, compute the mass of each size increment of the original sample as follows:

$$A = \frac{W_1}{W_2} \times B \qquad (1)$$

where:

A = mass of size increment on total sample basis,
W_1 = mass of fraction finer than 4.75-mm (No. 4) sieve in total sample,
W_2 = mass of reduced portion of material finer than 4.75-mm (No. 4) sieve actually sieved, and
B = mass of size increment in reduced portion sieved.

8.6 Unless a mechanical sieve shaker is used, hand sieve particles larger than 75 mm [3 in.] by determining the smallest

TABLE 1 Maximum Allowable Quantity of Material Retained on a Sieve, kg [lb]

Sieve Opening Size, mm	Nominal Dimensions of Sieve[A]				
	[8-in.] diameter[B]	[10-in.] diameter[B]	[12-in.] diameter[B]	[14-in. by 14-in.]	[14.5-in. by 23-in.]
	Sieving Area, m^2 [ft^2]				
	0.0285 [0.3]	0.0457 [0.5]	0.0670 [0.7]	0.1225 [1.3]	0.2158 [2.3]
125	C	C	C	C	67.4 [148½]
100	C	C	C	30.6 [67½]	53.9 [118¾]
90	C	C	15.1 [33¼]	27.6 [60¾]	48.5 [106¾]
75	C	8.6 [19]	12.6 [27¾]	23.0 [50¾]	40.5 [89¼]
63	C	7.2 [15¾]	10.6 [23¼]	19.3 [42½]	34.0 [75]
50	3.6 [8]	5.7 [13]	8.4 [18½]	15.3 [33¾]	27.0 [59½]
37.5	2.7 [6]	4.3 [9½]	6.3 [13¾]	11.5 [25¼]	20.2 [44½]
25.0	1.8 [4]	2.9 [6½]	4.2 [9¼]	7.7 [17]	13.5 [29¾]
19.0	1.4 [3½]	2.2 [4¾]	3.2 [7½]	5.8 [12¾]	10.2 [22½]
12.5	0.89 [2]	1.4 [3]	2.1 [4¾]	3.8 [8¼]	6.7 [14¾]
9.5	0.67 [1½]	1.1 [2½]	1.6 [3½]	2.9 [6¼]	5.1 [11¼]
4.75	0.33 [¾]	0.54 [1¼]	0.80 [1¾]	1.5 [3¼]	2.6 [5¾]

[A] Sieve frame dimensions in inch units: 8.0-in. diameter; 10.0-in. diameter, 12.0-in. diameter; 13.8 by 13.8 in. (14 by 14 in. nominal); 14.6 by 22.8 in. (16 by 24 in. nominal).
[B] The sieve area for round sieve frames is based on an effective diameter 12.5 mm [½ in.] less than the nominal frame diameter, because Specification E11 permits the sealer between the sieve cloth and the frame to extend 6.5 mm [¼ in.] over the sieve cloth. Thus the effective sieving diameter for a 203-mm [8.0-in.] diameter sieve frame is 190.5 mm [7.5 in.]. Sieves produced by some manufacturers do not infringe on the sieve cloth by the full 6.5 mm [¼ in.].
[C] Sieves indicated have less than five full openings. Do not use for sieve testing except as provided in 8.6.

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sieve opening through which each particle will pass. Start the test on the smallest sieve to be used. Rotate the particles, if necessary, in order to determine whether they will pass through a particular opening; however, do not force particles to pass through an opening.

8.7 Determine the mass of each size increment on a scale or balance conforming to the requirements specified in 5.1 to the nearest 0.1 % of the total original dry sample mass. Compare the total mass of the material after sieving to the original dry sample mass placed on the sieves. If the amounts differ by more than 0.3 %, based on the original dry sample mass, do not use the results for acceptance purposes.

8.8 If the sample has previously been tested by Test Method C117, add the mass finer than the 75-µm (No. 200) sieve determined by that test method to the mass passing the 75-µm (No. 200) sieve by dry sieving of the same sample in this test method.

9. Calculation

9.1 Calculate percentages passing, total percentages retained, or percentages in various size fractions to the nearest 0.1 % on the basis of the total mass of the initial dry sample. If the same test sample was first tested by Test Method C117, include the mass of material finer than the 75-µm (No. 200) size by washing in the sieve analysis calculation; and use the total dry sample mass prior to washing in Test Method C117 as the basis for calculating all the percentages.

9.1.1 When sample increments are tested as provided in 7.6, total the masses of the portion of the increments retained on each sieve, and use these masses to calculate the percentages as in 9.1.

9.2 Calculate the fineness modulus, when required, by adding the total percentages of material in the sample that is coarser than each of the following sieves (cumulative percentages retained), and dividing the sum by 100: 150-µm (No. 100), 300-µm (No. 50), 600-µm (No. 30), 1.18-mm (No. 16), 2.36-mm (No. 8), 4.75-mm (No. 4), 9.5-mm (3⁄8-in.), 19.0-mm (3⁄4-in.), 37.5-mm (1½-in.), and larger, increasing in the ratio of 2 to 1.

10. Report

10.1 Depending upon the form of the specifications for use of the material under test, the report shall include the following:

10.1.1 Total percentage of material passing each sieve, or

10.1.2 Total percentage of material retained on each sieve, or

10.1.3 Percentage of material retained between consecutive sieves.

10.2 Report percentages to the nearest whole number, except if the percentage passing the 75-µm (No. 200) sieve is less than 10 %, it shall be reported to the nearest 0.1 %.

10.3 Report the fineness modulus, when required, to the nearest 0.01.

11. Precision and Bias

11.1 *Precision*—The estimates of precision for this test method are listed in Table 2. The estimates are based on the results from the AASHTO Materials Reference Laboratory Proficiency Sample Program, with testing conducted by Test Method C136 and AASHTO No. T 27. The data are based on the analyses of the test results from 65 to 233 laboratories that tested 18 pairs of coarse aggregate proficiency test samples and test results from 74 to 222 laboratories that tested 17 pairs of fine aggregate proficiency test samples (Samples No. 21 through 90). The values in the table are given for different ranges of total percentage of aggregate passing a sieve.

11.1.1 The precision values for fine aggregate in Table 2 are based on nominal 500-g test samples. Revision of this test method in 1994 permits the fine aggregate test sample size to be 300 g minimum. Analysis of results of testing of 300-g and 500-g test samples from Aggregate Proficiency Test Samples 99 and 100 (Samples 99 and 100 were essentially identical) produced the precision values in Table 3, which indicate only minor differences due to test sample size.

NOTE 7—The values for fine aggregate in Table 2 will be revised to reflect the 300-g test sample size when a sufficient number of Aggregate Proficiency Tests have been conducted using that sample size to provide reliable data.

TABLE 2 Precision

	Total Percentage of Material Passing		Standard Deviation (1s), %[A]	Acceptable Range of Two Results (d2s), %[A]
Coarse Aggregate:[B]				
Single-operator precision	<100	≥95	0.32	0.9
	<95	≥85	0.81	2.3
	<85	≥80	1.34	3.8
	<80	≥60	2.25	6.4
	<60	≥20	1.32	3.7
	<20	≥15	0.96	2.7
	<15	≥10	1.00	2.8
	<10	≥5	0.75	2.1
	<5	≥2	0.53	1.5
	<2	>0	0.27	0.8
Multilaboratory precision	<100	≥95	0.35	1.0
	<95	≥85	1.37	3.9
	<85	≥80	1.92	5.4
	<80	≥60	2.82	8.0
	<60	≥20	1.97	5.6
	<20	≥15	1.60	4.5
	<15	≥10	1.48	4.2
	<10	≥5	1.22	3.4
	<5	≥2	1.04	3.0
	<2	>0	0.45	1.3
Fine Aggregate:				
Single-operator precision	<100	≥95	0.26	0.7
	<95	≥60	0.55	1.6
	<60	≥20	0.83	2.4
	<20	≥15	0.54	1.5
	<15	≥10	0.36	1.0
	<10	≥2	0.37	1.1
	<2	>0	0.14	0.4
Multilaboratory precision	<100	≥95	0.23	0.6
	<95	≥60	0.77	2.2
	<60	≥20	1.41	4.0
	<20	≥15	1.10	3.1
	<15	≥10	0.73	2.1
	<10	≥2	0.65	1.8
	<2	>0	0.31	0.9

[A] These numbers represent, respectively, the (1s) and (d2s) limits described in Practice C670.
[B] The precision estimates are based on aggregates with nominal maximum size of 19.0 mm (3⁄4 in.).

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TABLE 3 Precision Data for 300-g and 500-g Test Samples

Fine Aggregate Proficiency Sample				Within Laboratory		Between Laboratory	
Test Result	Sample Size	Number Labs	Average	1s	d2s	1s	d2s
Test Method C136/AASHTO No. T 27							
Total material passing the 4.75-mm No. 4 sieve (%)	500 g	285	99.992	0.027	0.066	0.037	0.104
	300 g	276	99.990	0.021	0.060	0.042	0.117
Total material passing the 2.36-mm No. 8 sieve (%)	500 g	281	84.10	0.43	1.21	0.63	1.76
	300 g	274	84.32	0.39	1.09	0.69	1.92
Total material passing the 1.18-mm No. 16 sieve (%)	500 g	286	70.11	0.53	1.49	0.75	2.10
	300 g	272	70.00	0.62	1.74	0.76	2.12
Total material passing the 600 µm No. 30 sieve (%)	500 g	287	48.54	0.75	2.10	1.33	3.73
	300 g	276	48.44	0.87	2.44	1.36	3.79
Total material passing the 300 µm No. 50 sieve (%)	500 g	286	13.52	0.42	1.17	0.98	2.73
	300 g	275	13.51	0.45	1.25	0.99	2.76
Total material passing the 150 µm No. 100 sieve (%)	500 g	287	2.55	0.15	0.42	0.37	1.03
	300 g	270	2.52	0.18	0.52	0.32	0.89
Total material passing the 75 µm No. 200 sieve (%)	500 g	278	1.32	0.11	0.32	0.31	0.85
	300 g	266	1.30	0.14	0.39	0.31	0.85

11.2 *Bias*—Since there is no accepted reference material suitable for determining the bias in this test method, no statement on bias is made.

12. Keywords

12.1 aggregate; coarse aggregate; fine aggregate; gradation; grading; sieve analysis; size analysis

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this test method since the last issue, C136 – 14, that may impact the use of this test method. (Approved Dec. 1, 2019)

(1) Revised 5.2, Footnote C of Table 1, and 8.7.

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Designation: C127 – 15

Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate[1]

This standard is issued under the fixed designation C127; 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 U.S. Department of Defense.

1. Scope

1.1 This test method covers the determination of relative density (specific gravity) and the absorption of coarse aggregates. The relative density (specific gravity), a dimensionless quantity, is expressed as oven-dry (OD), saturated-surface-dry (SSD), or as apparent relative density (apparent specific gravity). The OD relative density is determined after drying the aggregate. The SSD relative density and absorption are determined after soaking the aggregate in water for a prescribed duration.

1.2 This test method is not intended to be used with lightweight aggregates that comply with Specification C332 Group I aggregates.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 The text of this test method references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this test method.

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]

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
C125 Terminology Relating to Concrete and Concrete Aggregates
C128 Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate
C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates
C330 Specification for Lightweight Aggregates for Structural Concrete
C332 Specification for Lightweight Aggregates for Insulating Concrete
C566 Test Method for Total Evaporable Moisture Content of Aggregate by Drying
C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
C702 Practice for Reducing Samples of Aggregate to Testing Size
D75 Practice for Sampling Aggregates
D448 Classification for Sizes of Aggregate for Road and Bridge Construction
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2 *AASHTO Standard:*

AASHTO T 85 Specific Gravity and Absorption of Coarse Aggregate[3]

3. Terminology

3.1 For definition of terms used in this standard, refer to Terminology C125.

4. Summary of Test Method

4.1 A sample of aggregate is immersed in water for 24 ± 4 h to essentially fill the pores. It is then removed from the water, the water dried from the surface of the particles, and the mass determined. Subsequently, the volume of the sample is determined by the displacement of water method. Finally, the sample is oven-dried and the mass determined. Using the mass

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregatesand is the direct responsibility of Subcommittee C09.20 on Normal Weight Aggregates.

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[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.

[3] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

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values thus obtained and formulas in this test method, it is possible to calculate relative density (specific gravity) and absorption.

5. Significance and Use

5.1 Relative density (specific gravity) is the ratio of mass of an aggregate to the mass of a volume of water equal to the volume of the aggregate particles – also referred to as the absolute volume of the aggregate. It is also expressed as the ratio of the density of the aggregate particles to the density of water. Distinction is made between the density of aggregate particles and the bulk density of aggregates as determined by Test Method **C29/C29M**, which includes the volume of voids between the particles of aggregates.

5.2 Relative density is used to calculate the volume occupied by the aggregate in various mixtures containing aggregate, including hydraulic cement concrete, bituminous concrete, and other mixtures that are proportioned or analyzed on an absolute volume basis. Relative density (specific gravity) is also used in the computation of voids in aggregate in Test Method **C29/C29M**. Relative density (specific gravity) (SSD) is used if the aggregate is in a saturated-surface-dry condition, that is, if its absorption has been satisfied. Alternatively, the relative density (specific gravity) (OD) is used for computations when the aggregate is dry or assumed to be dry.

5.3 Apparent relative density (specific gravity) pertain to the solid material making up the constituent particles not including the pore space within the particles that is accessible to water.

5.4 Absorption values are used to calculate the change in the mass of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition, when it is deemed that the aggregate has been in contact with water long enough to satisfy most of the absorption potential. The laboratory standard for absorption is that obtained after submerging dry aggregate for a prescribed period of time. Aggregates mined from below the water table commonly have a moisture content greater than the absorption determined by this test method, if used without opportunity to dry prior to use. Conversely, some aggregates that have not been continuously maintained in a moist condition until used are likely to contain an amount of absorbed moisture less than the 24-h soaked condition. For an aggregate that has been in contact with water and that has free moisture on the particle surfaces, the percentage of free moisture is determined by deducting the absorption from the total moisture content determined by Test Method C566.

5.5 The general procedures described in this test method are suitable for determining the absorption of aggregates that have had conditioning other than the 24-h soak, such as boiling water or vacuum saturation. The values obtained for absorption by other test methods will be different than the values obtained by the prescribed soaking, as will the relative density (specific gravity) (SSD).

6. Apparatus

6.1 *Balance*—A device for determining mass that is sensitive, readable, and accurate to 0.05 % of the sample mass at any point within the range used for this test, or 0.5 g, whichever is greater. The balance shall be equipped with suitable apparatus for suspending the sample container in water from the center of the platform or pan of the balance.

6.2 *Sample Container*—A wire basket of 3.35 mm (No. 6) or finer mesh, or a bucket of approximately equal breadth and height, with a capacity of 4 to 7 L for 37.5-mm (1½-in.) nominal maximum size aggregate or smaller, and a larger container as needed for testing larger maximum size aggregate. The container shall be constructed so as to prevent trapping air when the container is submerged.

6.3 *Water Tank*—A watertight tank into which the sample container is placed while suspended below the balance.

6.4 *Sieves*—A 4.75-mm (No. 4) sieve or other sizes as needed (see 7.2 – 7.4), conforming to Specification E11.

6.5 *Oven*—An oven of sufficient size, capable of maintaining a uniform temperature of 110 ± 5 °C (230 ± 9 °F).

7. Sampling

7.1 Sample the aggregate in accordance with Practice D75.

7.2 Thoroughly mix the sample of aggregate and reduce it to the approximate quantity needed using the applicable procedures in Practice C702. Reject all material passing a 4.75-mm (No. 4) sieve by dry sieving and thoroughly washing to remove dust or other coatings from the surface. If the coarse aggregate contains a substantial quantity of material finer than the 4.75-mm sieve (such as for Size No. 8 and 9 aggregates in Classification D448), use the 2.36-mm (No. 8) sieve in place of the 4.75-mm sieve. Alternatively, separate the material finer than the 4.75-mm sieve and test the finer material according to Test Method C128.

NOTE 1—If aggregates smaller than 4.75 mm (No. 4) are used in the sample, check to ensure that the size of the openings in the sample container is smaller than the minimum size aggregate.

7.3 The minimum mass of test sample to be used is given as follows. Testing the coarse aggregate in several size fractions is permitted. If the sample contains more than 15 % retained on the 37.5-mm (1½-in.) sieve, test the material larger than 37.5 mm in one or more size fractions separately from the smaller size fractions. When an aggregate is tested in separate size fractions, the minimum mass of test sample for each fraction shall be the difference between the masses prescribed for the maximum and minimum sizes of the fraction.

Nominal Maximum Size, mm (in.)	Minimum Mass of Test Sample, kg (lb)
12.5 (½) or less	2 (4.4)
19.0 (¾)	3 (6.6)
25.0 (1)	4 (8.8)
37.5 (1½)	5 (11)
50 (2)	8 (18)
63 (2½)	12 (26)
75 (3)	18 (40)
90 (3½)	25 (55)
100 (4)	40 (88)
125 (5)	75 (165)

7.4 If the sample is tested in two or more size fractions, determine the grading of the sample in accordance with Test Method C136, including the sieves used for separating the size fractions for the determinations in this method. In calculating

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the percentage of material in each size fraction, ignore the quantity of material finer than the 4.75-mm (No. 4) sieve (or 2.36-mm (No. 8) sieve when that sieve is used in accordance with 7.2).

NOTE 2—When testing coarse aggregate of large nominal maximum size requiring large test samples, it may be more convenient to perform the test on two or more subsamples, and the values obtained combined for the computations described in Section 9.

8. Procedure

8.1 Dry the test sample in the oven to constant mass at a temperature of 110 ± 5 °C, cool in air at room temperature for 1 to 3 h for test samples of 37.5-mm (1½-in.) nominal maximum size, or longer for larger sizes until the aggregate has cooled to a temperature that is comfortable to handle (approximately 50 °C). Subsequently immerse the aggregate in water at room temperature for a period of 24 ± 4 h. When Specification C330 or Specification C332 Group II lightweight aggregates are used, immerse the aggregate in water at room temperature for a period of 72 ± 4 h, stirring for at least one minute every 24 h.

8.2 When the absorption and relative density (specific gravity) values are to be used in proportioning concrete mixtures in which the aggregates will be in their naturally moist condition, the requirement in 8.1 for initial drying is optional, and, if the surfaces of the particles in the sample have been kept continuously wet until tested, the requirement in 8.1 for 24 ± 4 h or 72 ± 4 h soaking is also optional.

NOTE 3—Values for absorption and relative density (specific gravity) (SSD) may be significantly higher for aggregate not oven dried before soaking than for the same aggregate treated in accordance with 8.1. This is especially true of particles larger than 75 mm since the water may not be able to penetrate the pores to the center of the particle in the prescribed soaking period.

8.3 Remove the test sample from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually. A moving stream of air is permitted to assist in the drying operation. Take care to avoid evaporation of water from aggregate pores during the surface-drying operation. Determine the mass of the test sample in the saturated surface-dry condition. Record this and all subsequent masses to the nearest 0.5 g or 0.05 % of the sample mass, whichever is greater.

8.4 After determining the mass in air, immediately place the saturated-surface-dry test sample in the sample container and determine its apparent mass in water at 23 ± 2.0 °C. Take care to remove all entrapped air before determining its mass by shaking the container while immersed.

NOTE 4—The difference between the mass in air and the mass when the sample is submerged in water equals the mass of water displaced by the sample.

NOTE 5—The container should be immersed to a depth sufficient to cover it and the test sample while determining the apparent mass in water. Wire suspending the container should be of the smallest practical size to minimize any possible effects of a variable immersed length.

8.5 Dry the test sample in the oven to constant mass at a temperature of 110 ± 5 °C, cool in air at room temperature 1 to 3 h, or until the aggregate has cooled to a temperature that is comfortable to handle (approximately 50 °C), and determine the mass.

9. Calculations

9.1 *Relative Density (Specific Gravity):*

9.1.1 *Relative Density (Specific Gravity) (OD)*—Calculate the relative density (specific gravity) on the basis of oven-dry aggregate as follows:

$$\text{Relative density (specific gravity) (OD)} = A/(B - C) \quad (1)$$

where:

A = mass of oven-dry test sample in air, g,
B = mass of saturated-surface-dry test sample in air, g, and
C = apparent mass of saturated test sample in water, g.

9.1.2 *Relative Density (Specific Gravity) (SSD)*—Calculate the relative density (specific gravity) on the basis of saturated-surface-dry aggregate as follows:

$$\text{Relative density (specific gravity) (SSD)} = B/(B - C) \quad (2)$$

9.1.3 *Apparent Relative Density (Specific Gravity)*—Calculate the apparent relative density (specific gravity) as follows:

$$\text{Apparent relative density (specific gravity)} = A/(A - C) \quad (3)$$

9.2 *Average Relative Density (Specific Gravity) Values*—If the sample is tested in separate size fractions, compute the average values for relative density (specific gravity) of the size fraction computed in accordance with 9.1 using the following equation:

$$G = \frac{1}{\frac{P_1}{100\,G_1} + \frac{P_2}{100\,G_2} + \ldots \frac{P_n}{100\,G_n}} \text{ (see Appendix X1)} \quad (4)$$

where:

G = average relative density (specific gravity). All forms of expression of relative density (specific gravity) can be averaged in this manner,
$G_1, G_2 \ldots G_n$ = appropriate average relative density (specific gravity) values for each size fraction depending on the type of relative density (specific gravity) being averaged, and
$P_1, P_2, \ldots P_n$ = mass percentages of each size fraction present in the original sample (not including finer material—see 7.4).

9.3 *Absorption*—Calculate the percentage of absorption, as follows:

$$\text{Absorption, \%} = [(B - A)/A] \times 100 \quad (5)$$

9.4 *Average Absorption Value*—If the sample is tested in separate size fractions, the average absorption value is the average of the values as computed in 9.3, weighted in proportion to the mass percentages of each size fraction present in the original sample (not including finer material—see 7.4) as follows:

$$A = (P_1A_1/100) + (P_2A_2/100) + \ldots (P_nA_n/100) \quad (6)$$

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where:

A = average absorption, %,
$A_1, A_2 ... A_n$ = absorption percentages for each size fraction, and
$P_1, P_2, ... P_n$ = mass percentages of each size fraction present in the original sample.

10. Report

10.1 Report relative density (specific gravity) results to the nearest 0.01 and indicate the basis for relative density (specific gravity) as either (OD), (SSD), or apparent.

10.2 Report the absorption result to the nearest 0.1 %.

10.3 If the relative density (specific gravity) and absorption values were determined without first drying the aggregate, as permitted in 8.2, note that fact in the report.

11. Precision and Bias

11.1 The estimates of precision of this test method listed in Table 1 are based on results from the AASHTO Materials Reference Laboratory Proficiency Sample Program, with testing conducted by this test method and AASHTO Method T 85. The significant difference between the methods is that Test Method C127 requires a saturation period of 24 ± 4 h, while AASHTO Method T 85 requires a saturation period of 15 h minimum. This difference has been found to have an insignificant effect on the precision indices. The data are based on the analyses of more than 100 paired test results from 40 to 100 laboratories.

TABLE 1 Precision

	Standard Deviation	Acceptable Range of Two Results (d2s)[A]
Single-Operator Precision:		
Relative density (specific gravity) (OD)	0.009	0.025
Relative density (specific gravity) (SSD)	0.007	0.020
Apparent relative density (specific gravity)	0.007	0.020
Multilaboratory Precision:		
Relative density (specific gravity) (OD)	0.013	0.038
Relative density (specific gravity) (SSD)	0.011	0.032
Apparent relative density (specific gravity)	0.011	0.032

[A] These numbers represent the (d2s) limits as described in Practice C670. The precision estimates were obtained from the analysis of combined AASHTO Materials Reference Laboratory proficiency sample data from laboratories using 15 h minimum saturation times and other laboratories using 24 ± 4 h saturation times. Testing was performed on normal-weight aggregates, and started with aggregates in the oven-dry condition.

11.2 *Bias*—Since there is no accepted reference material for determining the bias for the procedure in this test method, no statement on bias is being made.

12. Keywords

12.1 absorption; aggregate; apparent relative density; coarse aggregate; relative density; specific gravity

APPENDIXES

(Nonmandatory Information)

X1. DEVELOPMENT OF EQUATIONS

X1.1 The derivation of the equation is from the following simplified cases using two solids. Solid 1 has a mass M_1 in grams and a volume V_1 in millilitres; its relative density (specific gravity) (G_1) is therefore M_1/V_1. Solid 2 has a mass M_2 and volume V_2, and $G_2 = M_2/V_2$. If the two solids are considered together, the relative density (specific gravity) of the combination is the total mass in grams divided by the total volume in millilitres:

$$G = (M_1 + M_2)/(V_1 + V_2) \tag{X1.1}$$

Manipulation of this equation yields the following:

$$G = \frac{1}{\frac{V_1 + V_2}{M_1 + M_2}} = \frac{1}{\frac{V_1}{M_1 + M_2} + \frac{V_2}{M_1 + M_2}} \tag{X1.2}$$

$$G = \frac{1}{\frac{M_1}{M_1 + M_2}\left(\frac{V_1}{M_1}\right) + \frac{M_2}{M_1 + M_2}\left(\frac{V_2}{M_2}\right)} \tag{X1.3}$$

However, the mass fractions of the two solids are:

$$M_1/(M_1 + M_2) = P_1/100 \text{ and } M_2/(M_1 + M_2) = P_2/100 \tag{X1.4}$$

and,

$$1/G_1 = V_1/M_1 \text{ and } 1/G_2 = V_2/M_2 \tag{X1.5}$$

Therefore,

$$G = \frac{1}{\frac{P_1}{100}\frac{1}{G_1} + \frac{P_2}{100}\frac{1}{G_2}} \tag{X1.6}$$

An example of the computation is given in Table X1.1.

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TABLE X1.1 Example of Calculation of Weighted Values of Relative Density (Specific Gravity) and Absorption for a Coarse Aggregate Tested in Separate Sizes

Size Fraction, mm (in.)	% in Original Sample	Sample Mass Used in Test, g	Relative Density (Specific Gravity) (SSD)	Absorption, %
4.75 to 12.5 (No. 4 to ½)	44	2213.0	2.72	0.4
12.5 to 37.5 (½ to 1½)	35	5462.5	2.56	2.5
37.5 to 63 (1½ to 2½)	21	12593.0	2.54	3.0

Average Relative Density (Specific Gravity) (SSD)

$$G_{SSD} = \frac{1}{\frac{0.44}{2.72} + \frac{0.35}{2.56} + \frac{0.21}{2.54}} = 2.62$$

Average Absorption

$$A = (0.44)\,(0.4) + (0.35)\,(2.5) + (0.21)\,(3.0) = 1.7\,\%$$

X2. INTERRELATIONSHIPS BETWEEN RELATIVE DENSITIES (SPECIFIC GRAVITIES) AND ABSORPTION AS DEFINED IN TEST METHODS C127 AND C128

X2.1 Where:

S_d = relative density (specific gravity) (OD),
S_s = relative density (specific gravity) (SSD),
S_a = apparent relative density (apparent specific gravity), and
A = absorption in %.

X2.2 Calculate the values of each as follows:

$$S_s = (1 + A/100) S_d \quad \text{(X2.1)}$$

$$S_a = \frac{1}{\frac{1}{S_d} - \frac{A}{100}} = \frac{S_d}{1 - \frac{AS_d}{100}} \quad \text{(X2.2)}$$

$$S_a = \frac{1}{\frac{1 + A/100}{S_s} - \frac{A}{100}} = \frac{S_s}{1 - \left[\frac{A}{100}(S_s - 1)\right]} \quad \text{(X2.3)}$$

$$A = \left(\frac{S_s}{S_d} - 1\right) 100 \quad \text{(X2.4)}$$

$$A = \left(\frac{S_a - S_s}{S_a(S_s - 1)}\right) 100 \quad \text{(X2.5)}$$

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INTERNATIONAL

Designation: C128 – 15

Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate[1]

This standard is issued under the fixed designation C128; 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.

1. Scope

1.1 This test method covers the determination of relative density (specific gravity) and the absorption of fine aggregates. The relative density (specific gravity), a dimensionless quality, is expressed as oven-dry (OD), saturated-surface-dry (SSD), or as apparent relative density (specific gravity). The OD relative density is determined after drying the aggregate. The SSD relative density and absorption are determined after soaking the aggregate in water for a prescribed duration.

1.2 This test method is not intended to be used for lightweight aggregates that comply with Specification C332 Group I aggregates.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 The text of this test method references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this test method.

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]

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

C70 Test Method for Surface Moisture in Fine Aggregate

C117 Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing

C125 Terminology Relating to Concrete and Concrete Aggregates

C127 Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate

C330 Specification for Lightweight Aggregates for Structural Concrete

C332 Specification for Lightweight Aggregates for Insulating Concrete

C188 Test Method for Density of Hydraulic Cement

C566 Test Method for Total Evaporable Moisture Content of Aggregate by Drying

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

C702 Practice for Reducing Samples of Aggregate to Testing Size

C1252 Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading) (Withdrawn 2015)[3]

D75 Practice for Sampling Aggregates

D854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

2.2 *AASHTO Standard:*

AASHTO T 84 Specific Gravity and Absorption of Fine Aggregates[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this standard, refer to Terminology C125.

4. Summary of Test Method

4.1 A sample of aggregate is immersed in water for 24 ± 4 h to essentially fill the pores. It is then removed from the water, the water is dried from the surface of the particles, and the mass determined. Subsequently, the sample (or a portion of it) is placed in a graduated container and the volume of the sample is determined by the gravimetric or volumetric method. Finally,

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregatesand is the direct responsibility of Subcommittee C09.20 on Normal Weight Aggregates.

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[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

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the sample is oven-dried and the mass determined again. Using the mass values thus obtained and formulas in this test method, it is possible to calculate relative density (specific gravity) and absorption.

5. Significance and Use

5.1 Relative density (specific gravity) is the ratio of mass of an aggregate to the mass of a volume of water equal to the volume of the aggregate particles – also referred to as the absolute volume of the aggregate. It is also expressed as the ratio of the density of the aggregate particles to the density of water. Distinction is made between the density of aggregate particles and the bulk density of aggregates as determined by Test Method C29/C29M, which includes the volume of voids between the particles of aggregates.

5.2 Relative density is used to calculate the volume occupied by the aggregate in various mixtures containing aggregate including hydraulic cement concrete, bituminous concrete, and other mixtures that are proportioned or analyzed on an absolute volume basis. Relative density (specific gravity) is also used in the computation of voids in aggregate in Test Method C29/C29M and in Test Method C1252. Relative density (specific gravity) (SSD) is used in the determination of surface moisture on fine aggregate by displacement of water in Test Method C70. Relative density (specific gravity) (SSD) is used if the aggregate is in a saturated surface-dry condition, that is, if its absorption has been satisfied. Alternatively, the relative density (specific gravity) (OD) is used for computations when the aggregate is dry or assumed to be dry.

5.3 Apparent relative density (specific gravity) pertain to the solid material making up the constituent particles not including the pore space within the particles that is accessible to water. This value is not widely used in construction aggregate technology.

5.4 Absorption values are used to calculate the change in the mass of an aggregate material due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition, if it is deemed that the aggregate has been in contact with water long enough to satisfy most of the absorption potential. The laboratory standard for absorption is that obtained after submerging dry aggregate for a prescribed period of time. Aggregates mined from below the water table commonly have a moisture content greater than the absorption determined by this test method, if used without opportunity to dry prior to use. Conversely, some aggregates that have not been continuously maintained in a moist condition until used are likely to contain an amount of absorbed moisture less than the 24-h soaked condition. For an aggregate that has been in contact with water and that has free moisture on the particle surfaces, the percentage of free moisture is determined by deducting the absorption from the total moisture content determined by Test Method C566 by drying.

5.5 The general procedures described in this test method are suitable for determining the absorption of aggregates that have had conditioning other than the 24-h soak, such as boiling water or vacuum saturation. The values obtained for absorption by other test methods will be different than the values obtained by the prescribed 24-h soak, as will the relative density (specific gravity) (SSD).

6. Apparatus

6.1 *Balance*—A balance or scale having a capacity of 1 kg or more, sensitive to 0.1 g or less, and accurate within 0.1 % of the test load at any point within the range of use for this test method. Within any 100-g range of test load, a difference between readings shall be accurate within 0.1 g.

6.2 *Pycnometer (for Use with Gravimetric Procedure)*—A flask or other suitable container into which the fine aggregate test sample can be readily introduced and in which the volume content can be reproduced within ± 0.1 cm^3. The volume of the container filled to mark shall be at least 50 % greater than the space required to accommodate the test sample. A volumetric flask of 500-cm^3 capacity or a fruit jar fitted with a pycnometer top is satisfactory for a 500-g test sample of most fine aggregates.

6.3 *Flask (for Use with Volumetric Procedure)*—A Le Chatelier flask as described in Test Method C188 is satisfactory for an approximately 55-g test sample.

6.4 *Mold and Tamper for Surface Moisture Test*—The metal mold shall be in the form of a frustum of a cone with dimensions as follows: 40 ± 3-mm inside diameter at the top, 90± 3-mm inside diameter at the bottom, and 75 ± 3 mm in height, with the metal having a minimum thickness of 0.8 mm. The metal tamper shall have a mass of 340 ± 15 g and a flat circular tamping face 25 ± 3 mm in diameter.

6.5 *Oven*—An oven of sufficient size, capable of maintaining a uniform temperature of 110 ± 5 °C (230 ± 9 °F).

7. Sampling

7.1 Sample the aggregate in accordance with Practice D75. Thoroughly mix the sample and reduce it to obtain a test specimen of approximately 1 kg using the applicable procedures described in Practice C702.

8. Preparation of Test Specimen

8.1 Place the test specimen in a suitable pan or vessel and dry in the oven to constant mass at a temperature of 110 ± 5 °C (230 ± 9 °F). Allow it to cool to comfortable handling temperature (approximately 50 °C), cover with water, either by immersion or by the addition of at least 6 % moisture to the fine aggregate, and permit to stand for 24 ± 4 h. When Specification C330 or Specification C332 Group II lightweight aggregates are used, immerse the aggregate in water at room temperature for a period of 72 ± 4 h, stirring for at least one minute every 24 h.

8.1.1 When the absorption and relative density (specific gravity) values are to be used in proportioning concrete mixtures in which the aggregates will be in their naturally moist condition, the requirement in 8.1 for initial drying is optional, and, if the surfaces of the particles in the sample have been kept continuously wet until tested, the requirement in 8.1 for 24 ± 4 h soaking or 72 ± 4 h is also optional.

NOTE 1—Values for absorption and for relative density (specific gravity) (SSD) may be significantly higher for aggregate not oven dried

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before soaking than for the same aggregate treated in accordance with 8.1.

8.2 Decant excess water with care to avoid loss of fines (see also Appendix X1), spread the sample on a flat nonabsorbent surface exposed to a gently moving current of warm air, and stir frequently to secure homogeneous drying. Employ mechanical aids such as tumbling or stirring to assist in achieving the saturated surface-dry condition, if desired. Continue this operation until the test specimen approaches a free-flowing condition. Follow the procedure in 8.3 to determine if surface moisture is still present on the constituent fine aggregate particles. Make the first trial for surface moisture when there is still some surface water in the test specimen. Continue drying with constant stirring and test at frequent intervals until the test indicates that the specimen has reached a surface-dry condition. If the first trial of the surface moisture test indicates that moisture is not present on the surface, it has been dried past the saturated surface-dry condition. In this case, thoroughly mix a few millilitres of water with the fine aggregate and permit the specimen to stand in a covered container for 30 min. Then resume the process of drying and testing at frequent intervals for the onset of the surface-dry condition.

8.3 *Test for Surface Moisture*—Hold the mold firmly on a smooth nonabsorbent surface with the large diameter down. Place a portion of the partially dried fine aggregate loosely in the mold by filling it to overflowing and heaping additional material above the top of the mold by holding it with the cupped fingers of the hand holding the mold. Lightly tamp the fine aggregate into the mold with 25 light drops of the tamper. Start each drop approximately 5 mm above the top surface of the fine aggregate. Permit the tamper to fall freely under gravitational attraction on each drop. Adjust the starting height to the new surface elevation after each drop and distribute the drops over the surface. Remove loose sand from the base and lift the mold vertically. If surface moisture is still present, the fine aggregate will retain the molded shape. Slight slumping of the molded fine aggregate indicates that it has reached a surface-dry condition.

8.3.1 Some fine aggregate with predominately angular-shaped particles or with a high proportion of fines does not slump in the cone test upon reaching the surface-dry condition. Test by dropping a handful of the fine aggregate from the cone test onto a surface from a height of 100 to 150 mm, and observe for fines becoming airborne; presence of airborne fines indicates this problem. For these materials, consider the saturated surface-dry condition as the point that one side of the fine aggregate slumps slightly upon removing the mold.

NOTE 2—The following criteria have also been used on materials that do not readily slump:

(1) Provisional Cone Test—Fill the cone mold as described in 8.3 except only use 10 drops of the tamper. Add more fine aggregate and use 10 drops of the tamper again. Then add material two more times using 3 and 2 drops of the tamper, respectively. Level off the material even with the top of the mold, remove loose material from the base; and lift the mold vertically.

(2) Provisional Surface Test—If airborne fines are noted when the fine aggregate is such that it will not slump when it is at a moisture condition, add more moisture to the sand, and at the onset of the surface-dry condition, with the hand lightly pat approximately 100 g of the material on a flat, dry, clean, dark or dull nonabsorbent surface such as a sheet of rubber, a worn oxidized, galvanized, or steel surface, or a black-painted metal surface. After 1 to 3 s, remove the fine aggregate. If noticeable moisture shows on the test surface for more than 1 to 2 s then surface moisture is considered to be present on the fine aggregate.

(3) Colorimetric procedures described by Kandhal and Lee, Highway Research Record No. 307, p. 44.

(4) For reaching the saturated surface-dry condition on a single size material that slumps when wet, hard-finish paper towels can be used to surface dry the material until the point is just reached where the paper towel does not appear to be picking up moisture from the surfaces of the fine aggregate particles.

9. Procedure

9.1 Test by either the gravimetric procedure in 9.2 or the volumetric procedure in 9.3. Make all determinations of mass to 0.1 g.

9.2 *Gravimetric (Pycnometer) Procedure:*

9.2.1 Partially fill the pycnometer with water. Introduce into the pycnometer 500 ± 10 g of saturated surface-dry fine aggregate prepared as described in Section 8, and fill with additional water to approximately 90 % of capacity. Agitate the pycnometer as described in 9.2.1.1 (manually) or 9.2.1.2 (mechanically).

9.2.1.1 Manually roll, invert, or agitate the pycnometer (or use a combination of these actions) to eliminate visible air bubbles.

NOTE 3—About 15 to 20 min are normally required to eliminate the air bubbles by manual methods. Dipping the tip of a paper towel into the pycnometer has been found to be useful in dispersing the foam that sometimes builds up when eliminating the air bubbles. Optionally, a small amount of isopropyl alcohol may be used to disperse the foam.

9.2.1.2 Mechanically agitate the pycnometer by external vibration in a manner that will not degrade the sample. A level of agitation adjusted to just set individual particles in motion is sufficient to promote de-airing without degradation. A mechanical agitator shall be considered acceptable for use if comparison tests for each six-month period of use show variations less that the acceptable range of two results (d2s) indicated in Table 1 from the results of manual agitation on the same material.

9.2.2 After eliminating all air bubbles, adjust the temperature of the pycnometer and its contents to 23.0 ± 2.0 °C if necessary by partial immersion in circulating water, and bring the water level in the pycnometer to its calibrated capacity. Determine the total mass of the pycnometer, specimen, and water.

9.2.3 Remove the fine aggregate from the pycnometer, dry in the oven to constant mass at a temperature of 110 ± 5 °C (230 ± 9 °F), cool in air at room temperature for 1 ± ½ h, and determine the mass.

9.2.4 Determine the mass of the pycnometer filled to its calibrated capacity with water at 23.0 ± 2.0 °C.

9.3 *Volumetric (Le Chatelier Flask) Procedure:*

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9.3.1 Fill the flask initially with water to a point on the stem between the 0 and the 1-mL mark. Record this initial reading with flask and contents within the temperature range of 23.0 ± 2.0 °C. Add 55 ± 5 g of fine aggregate in the saturated surface-dry condition (or other measured quantity as necessary). After all fine aggregate has been introduced, place the stopper in the flask and roll the flask in an inclined position, or gently whirl it in a horizontal circle so as to dislodge all entrapped air, continuing until no further bubbles rise to the surface (Note 4). Take a final reading with the flask and contents within 1 °C of the original temperature.

NOTE 4—A small measured amount (not to exceed 1 mL) of isopropyl alcohol may be used to eliminate foam appearing on the water surface. The volume of alcohol used must be subtracted from the final reading (R_2).

9.3.2 For determination of the absorption, use a separate 500 ± 10-g portion of the saturated surface-dry fine aggregate, dry to constant mass, and determine the dry mass.

10. Calculations

10.1 *Symbols:* A = mass of oven dry specimen, g

B = mass of pycnometer filled with water, to calibration mark, g

C = mass of pycnometer filled with specimen and water to calibration mark, g

R_1 = initial reading of water level in Le Chatelier flask, mL

R_2 = final reading of water in Le Chatelier flask, mL

S = mass of saturated surface-dry specimen (used in the gravimetric procedure for density and relative density (specific gravity), or for absorption with both procedures), g

S_1 = mass of saturated surface-dry specimen (used in the volumetric procedure for density and relative density (specific gravity)), g

10.2 *Relative Density (Specific Gravity):*

10.2.1 *Relative Density (Specific Gravity) (Oven dry)*—Calculate the relative density (specific gravity) on the basis of oven-dry aggregate as follows:

10.2.1.1 *Gravimetric Procedure:*

$$\text{Relative density (specific gravity) (OD)} = A/(B+S-C) \quad (1)$$

10.2.1.2 *Volumetric Procedure:*

$$\text{Relative density (specific gravity) (OD)} = [S_1\,(A/S)]/[0.9975\,(R_2 - R_1)] \quad (2)$$

10.2.2 *Relative Density (Specific Gravity) (Saturated Surface-dry)*—Calculate the relative density (specific gravity) on the basis of saturated surface-dry aggregate as follows:

10.2.2.1 *Gravimetric Procedure:*

$$\text{Relative density (specific gravity) (SSD)} = S/(B+S-C) \quad (3)$$

10.2.2.2 *Volumetric Procedure:*

$$\text{Relative density (specific gravity) (SSD)} = S_1/[0.9975\,(R_2 - R_1)] \quad (4)$$

10.2.3 *Apparent Relative Density (Specific Gravity)*—Calculate the apparent relative density (specific gravity) as follows:

10.2.3.1 *Gravimetric Procedure:*

$$\text{Apparent relative density (specific gravity)} = A/(B+A-C) \quad (5)$$

10.2.3.2 *Volumetric Procedure:*

$$\text{Apparent relative density (specific gravity)} = \frac{S_1\,(A/S)}{0.9975\,(R_2 - R_1) - [(S_1/S)(S-A)]} \quad (6)$$

10.3 *Absorption*—Calculate the percentage of absorption as follows:

$$\text{Absorption, \%} = 100\,[(S-A)/A] \quad (7)$$

11. Report

11.1 Report relative density (specific gravity) results to the nearest 0.01 and indicate the basis for relative density (specific gravity), as either oven-dry (OD), saturated-surface-dry (SSD), or apparent.

11.2 Report the absorption result to the nearest 0.1 %.

11.3 If the relative density (specific gravity) values were determined without first drying the aggregate, as permitted in 8.2, note that fact in the report.

12. Precision and Bias

12.1 *Precision*—The estimates of precision of this test method (listed in Table 1) are based on results from the AASHTO Materials Reference Laboratory Proficiency Sample Program, with testing conducted by this test method and AASHTO T 84. The significant difference between the methods is that Test Method C128 requires a saturation period of 24

TABLE 1 Precision

	Standard Deviation	Acceptable Range of Two Results (d2s)[A]
Single-Operator Precision		
Relative density (specific gravity) (OD)	0.011	0.032
Relative density (specific gravity) (SSD)	0.0095	0.027
Apparent relative density (specific gravity)	0.0095	0.027
Absorption,[B] %	0.11	0.31
Multilaboratory Precision		
Relative density (specific gravity) (OD)	0.023	0.066
Relative density (specific gravity) (SSD)	0.020	0.056
Apparent relative density (specific gravity)	0.020	0.056
Absorption,[B] %	0.23	0.66

[A] These numbers represent the (d2s) limits as described in Practice C670. The precision estimates were obtained from the analysis of combined AASHTO Materials Reference Laboratory proficiency sample data from laboratories using 15 to 19-h saturation times and other laboratories using 24 ± 4-h saturation time. Testing was performed on normal weight aggregates, and started with aggregates in the oven-dry condition.

[B] Precision estimates are based on aggregates with absorptions of less than 1 % and may differ for manufactured fine aggregates and the aggregates having absorption values greater than 1 %.

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± 4 h, and AASHTO Test Method T 84 requires a saturation period of 15 to 19 h. This difference has been found to have an insignificant effect on the precision indices. The data are based on the analyses of more than 100 paired test results from 40 to 100 laboratories.

12.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for this test method, no statement on bias is being made.

13. Keywords

13.1 absorption; aggregate; apparent relative density; fine aggregate; relative density; specific gravity

APPENDIXES

(Nonmandatory Information)

X1. POTENTIAL DIFFERENCES IN BULK RELATIVE DENSITY AND ABSORPTION DUE TO PRESENCE OF MATERIAL FINER THAN 75 µm

X1.1 It has been found that there may be significant differences in bulk relative density and absorption between fine aggregate samples tested with the material finer than 75 µm (No. 200) present and not present in the samples. Samples from which the material finer than 75 µm is not removed usually give a higher absorption and a lower bulk relative density compared with testing the same fine aggregate from which the material finer than 75 µm is removed following the procedures of Test Method C117. Samples with material finer than 75 µm may build up a coating around the coarser fine aggregate particles during the surface drying process. The resultant relative density and absorption that is subsequently measured is that of the agglomerated and coated particles and not that of the parent material. The difference in absorption and relative density determined between samples from which the material finer than 75 µm have not been removed and samples from which the material finer than 75 µm have been removed depends on both the amount of the material finer than 75 µm present and the nature of the material. When the material finer than 75 µm is less than about 4 % by mass, the difference in relative density between washed and unwashed samples is less than 0.03. When the material finer than 75 µm is greater than about 8 % by mass, the difference in relative density obtained between washed and unwashed samples may be as great as 0.13. It has been found that the relative density determined on fine aggregate from which the material finer than 75 µm has been removed prior to testing more accurately reflects the relative density of the material.

X1.2 The material finer than 75 µm, which is removed, can be assumed to have the same relative density as the fine aggregate. Alternatively, the relative density (specific gravity) of the material finer than 75 µm may be further evaluated using Test Method D854, however, this test determines the apparent relative density and not the bulk relative density.

X2. INTERRELATIONSHIPS BETWEEN RELATIVE DENSITIES (SPECIFIC GRAVITIES) AND ABSORPTION AS DEFINED IN TEST METHODS C127 AND C128

X2.1 This appendix gives mathematical interrelationships among the three types of relative densities (specific gravities) and absorption. These may be useful in checking the consistency of reported data or calculating a value that was not reported by using other reported data.

X2.2 Where:

S_d = relative density (specific gravity) (OD),
S_s = relative density (specific gravity) (SSD),
S_a = apparent relative density (apparent specific gravity), and
A = absorption, in %.

Calculate the values of each as follows:

$$S_s = (1 + A/100)S_d \quad \text{(X2.1)}$$

$$S_s = \frac{1}{\frac{1}{S_d} - \frac{A}{100}} = \frac{S_d}{1 - \frac{AS_d}{100}} \quad \text{(X2.2)}$$

$$\text{or } S_a = \frac{1}{\frac{1 + A/100}{S_s} - \frac{A}{100}} \quad \text{(X2.3)}$$

$$= \frac{S_s}{1 = \frac{A}{100}(S_s - 1)}$$

$$A = \left(\frac{S_s}{S_d} - 1\right) 100 \quad \text{(X2.4)}$$

$$A = \left(\frac{S_a - S_s}{S_a(S_s - 1)}\right) 100 \quad \text{(X2.5)}$$

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

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Designation: C33/C33M – 18

Standard Specification for Concrete Aggregates[1]

This standard is issued under the fixed designation C33/C33M; 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.

1. Scope*

1.1 This specification defines the requirements for grading and quality of fine and coarse aggregate (other than lightweight or heavyweight aggregate) for use in concrete.[2]

1.2 This specification is for use by a contractor, concrete supplier, or other purchaser as part of the purchase document describing the material to be furnished.

NOTE 1—This specification is regarded as adequate to ensure satisfactory materials for most concrete. It is recognized that, for certain work or in certain regions, it may be either more or less restrictive than needed. For example, where aesthetics are important, more restrictive limits may be considered regarding impurities that would stain the concrete surface. The specifier should ascertain that aggregates specified are or can be made available in the area of the work, with regard to grading, physical, or chemical properties, or combination thereof.

1.3 This specification is also for use in project specifications to define the quality of aggregate, the nominal maximum size of the aggregate, and other specific grading requirements. Those responsible for selecting the proportions for the concrete mixture shall have the responsibility of determining the proportions of fine and coarse aggregate and the addition of blending aggregate sizes if required or approved.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. 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.

1.5 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this standard.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
C40/C40M Test Method for Organic Impurities in Fine Aggregates for Concrete
C87/C87M Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
C88 Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
C117 Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing
C123/C123M Test Method for Lightweight Particles in Aggregate
C125 Terminology Relating to Concrete and Concrete Aggregates
C131/C131M Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
C136/C136M Test Method for Sieve Analysis of Fine and Coarse Aggregates
C142/C142M Test Method for Clay Lumps and Friable Particles in Aggregates
C294 Descriptive Nomenclature for Constituents of Concrete Aggregates
C295/C295M Guide for Petrographic Examination of Aggregates for Concrete
C330/C330M Specification for Lightweight Aggregates for Structural Concrete
C331/C331M Specification for Lightweight Aggregates for Concrete Masonry Units
C332 Specification for Lightweight Aggregates for Insulating Concrete

[1] This specification is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.20 on Aggregates.

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[2] For lightweight aggregates, see Specifications C330/C330M, C331/C331M, and C332; for heavyweight aggregates see Specification C637 and Descriptive Nomenclature C638.

[3] 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

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C535 Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
C637 Specification for Aggregates for Radiation-Shielding Concrete
C638 Descriptive Nomenclature of Constituents of Aggregates for Radiation-Shielding Concrete
C666/C666M Test Method for Resistance of Concrete to Rapid Freezing and Thawing
C1778 Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete
D75/D75M Practice for Sampling Aggregates
D422 Test Method for Particle-Size Analysis of Soils (Withdrawn 2016)[4]
D2419 Test Method for Sand Equivalent Value of Soils and Fine Aggregate
D3665 Practice for Random Sampling of Construction Materials
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2 *Other Standards:*
AASHTO T 330 Method of Test for the Qualitative Detection of Harmful Clays of the Smectite Group in Aggregates Using Methylene Blue[5]

3. Terminology

3.1 For definitions of terms used in this standard, refer to Terminology C125.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aggregate, recycled, n*—granular material that has been diverted, separated, or removed from the solid waste stream, and processed for use in the form of raw materials or products.

4. Ordering and Specifying Information

4.1 The direct purchaser of aggregates shall include the information in 4.2 in the purchase order as applicable. A project specifier shall include in the project documents information to describe the aggregate to be used in the project from the applicable items in 4.3.

4.2 Include in the purchase order for aggregates the following information, as applicable:

4.2.1 Reference to this specification, as C33____,

4.2.2 Whether the order is for fine aggregate or for coarse aggregate,

4.2.3 Quantity, in metric tons or tons,

4.2.4 When the order is for fine aggregate:

4.2.4.1 Requirements for alkali-aggregate reactivity (see 7.3),

4.2.4.2 In the case of the sulfate soundness test (see 8.1) which salt is to be used. If none is stated, either sodium sulfate or magnesium sulfate shall be used,

4.2.4.3 The appropriate limit for material finer than 75-µm (No. 200) sieve (see Table 1). If not stated, the 3.0 % limit shall apply,

4.2.4.4 The appropriate limit for coal and lignite (see Table 2). If not stated, the 1.0 % limit shall apply,

4.2.5 When the order is for coarse aggregate:

4.2.5.1 The grading (size number) (see 10.1 and Table 3), or alternate grading as agreed between the purchaser and aggregate supplier.

4.2.5.2 The class designation (see 11.1 and Table 4),

4.2.5.3 Requirements for alkali-aggregate reactivity (see 11.2),

4.2.5.4 In the case of the sulfate soundness test (see Table 4), which salt is to be used. If none is stated, either sodium sulfate or magnesium sulfate shall be used, and

4.2.6 Any exceptions or additions to this specification (see Note 1).

4.3 Include in project specifications for aggregates the following information, as applicable:

4.3.1 Reference to this specification, as C33____.

4.3.2 When the aggregate being described is fine aggregate:

4.3.2.1 Requirements for alkali-aggregate reactivity (see 7.3),

4.3.2.2 In the case of the sulfate soundness test (see 8.1) which salt is to be used. If none is stated, either sodium sulfate or magnesium sulfate shall be used.

4.3.2.3 The appropriate limit for material finer than the 75-µm (No. 200) sieve (see Table 1). If not stated, the 3.0 % limit shall apply, and

4.3.2.4 The limit that applies with regard to coal and lignite (Table 2). If not stated, the 1.0 % limit shall apply.

4.3.3 When the aggregate being described is coarse aggregate, include:

4.3.3.1 The nominal maximum size or sizes permitted, based on thickness of section or spacing of reinforcing bars or other criteria. In lieu of stating the nominal maximum size, the specifier shall designate an appropriate size number or numbers (see 10.1 and Table 3). Designation of a size number to indicate a nominal size shall not restrict the person responsible for selecting proportions from combining two or more gradings of aggregate to obtain a desired grading, provided that the

TABLE 1 Grading Requirements for Fine Aggregate

Sieve (Specification E11)	Percent Passing
9.5-mm (3/8-in.)	100
4.75-mm (No. 4)	95 to 100
2.36-mm (No. 8)	80 to 100
1.18-mm (No. 16)	50 to 85
600-µm (No. 30)	25 to 60
300-µm (No. 50)	5 to 30
150-µm (No. 100)	0 to 10
75-µm (No. 200)	0 to 3.0[A,B]

[A] For concrete not subject to abrasion, the limit for material finer than the 75-µm (No. 200) sieve shall be 5.0 % maximum.
[B] For manufactured fine or other recycled aggregate, if the material finer than the 75-µm (No. 200) sieve consists of the dust of fracture, essentially free of clay or shale, this limit shall be 5.0% for concrete subject to abrasion, and 7% maximum for concrete not subject to abrasion.

[4] The last approved version of this historical standard is referenced on www.astm.org.
[5] *AASHTO Standard Specifications, Part 2B: Tests.*Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

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TABLE 2 Limits for Deleterious Substances in Fine Aggregate for Concrete

Item	Mass Percent of Total Sample, max
Clay lumps and friable particles	3.0
Coal and lignite:	
Where surface appearance of concrete is of importance	0.5
All other concrete	1.0

gradings are not otherwise restricted by the project specifier and the nominal maximum size indicated by the size number is not exceeded,

4.3.3.2 The class designation (see 11.1 and Table 4),

4.3.3.3 Requirements for alkali-aggregate reactivity (see 11.2),

4.3.3.4 In the case of the sulfate soundness test (see Table 4), which salt is to be used. If none is stated, either sodium sulfate or magnesium sulfate shall be used, and

4.3.4 The person responsible for selecting the concrete proportions if other than the concrete producer.

4.3.5 Any exceptions or additions to this specification (see Note 1).

FINE AGGREGATE

5. General Characteristics

5.1 Fine aggregate shall consist of natural sand, manufactured sand, or other recycled aggregate, or a combination thereof.

NOTE 2—This standard only addresses properties of aggregates considered necessary for use in concrete and the associated test methods contained within this standard. Certain recycled aggregate sources may contain materials and properties not addressed as part of the document specifications, limits, or test methods. Recycled aggregates may require evaluation for environmental considerations (air quality, water quality, storage) using the appropriate local, state, and federal test methods in effect at the time of use.

6. Grading

6.1 *Sieve Analysis*—Fine aggregate, except as provided in 6.2 and 6.3 shall be graded within the limits in Table 1.

NOTE 3—Concrete with fine aggregate gradings near the minimums for percent passing the 300 µm (No.50) and 150 µm (No.100) sometimes have difficulties with workability, pumping or excessive bleeding. The addition of entrained air, additional cement, or the addition of an approved mineral admixture to supply the deficient fines, are methods used to alleviate such difficulties.

6.2 The fine aggregate shall have not more than 45 % passing any sieve and retained on the next consecutive sieve of those shown in 6.1, and its fineness modulus shall be not less than 2.3 nor more than 3.1.

6.3 Fine aggregate failing to meet these grading requirements shall meet the requirements of this section provided that the supplier can demonstrate to the purchaser or specifier that concrete of the class specified, made with fine aggregate under consideration, will have relevant properties (see Note 6) at least equal to those of concrete made with the same ingredients, with the exception that the reference fine aggregate shall be selected from a source having an acceptable performance record in similar concrete construction.

NOTE 4—Manufactured fine aggregate having elevated proportions of material passing the 75-µm (No. 200) sieve may need further evaluation to ensure that material passing the 75-µm (No. 200) sieve is essentially composed of dust of fracture derived from the parent rock in the crushing operation, and does not contain an appreciable level of clay minerals or other deleterious constituents as described in Descriptive Nomenclature C294. Because some of the dust of fracture may occur in the clay size range, defined here as material finer than 2 µm, care must be taken to properly differentiate these clay-sized materials from clay minerals. Natural fine aggregate with elevated proportions of material passing the 75-µm (No. 200) sieve may have higher potential for clay mineral content.

Various means are available for characterizing these fines, such as petrographic analysis (Guide C295/C295M), sand equivalent determination (Test Method D2419), hydrometer analysis (Test Method D422), methylene blue adsorption determination (AASHTO T 330) and X-ray diffraction analysis. While these techniques are useful for investigative purposes, no specific limits have been established for prediction of performance of these materials in concrete under various intended service conditions. Methylene blue adsorption and hydrometer analyses are believed to be two relatively quick and reliable tests for characterization of material passing the 75-µm (No. 200) sieve to determine suitability for use in concrete. Research (**1,2**) has indicated that manufactured fine aggregate with less than 4 % by mass finer than 2 µm, and with methylene blue adsorption values less than 5 mg/g generally is suitable for use in concrete. Fine aggregate that exceeds these values also may be suitable for use provided that fresh and hardened concrete properties are shown to be acceptable.

NOTE 5—Fine aggregate that conforms to the grading requirements of a specification, prepared by another organization such as a state transportation agency, which is in general use in the area, should be considered as having a satisfactory service record with regard to those concrete properties affected by grading.

NOTE 6—Relevant properties are those properties of the concrete that are important to the particular application being considered. STP 169D[6] provides a discussion of important concrete properties.

6.4 For continuing shipments of fine aggregate from a given source, the fineness modulus shall not vary more than 0.20 from the base fineness modulus. The base fineness modulus shall be that value that is typical of the source. The purchaser or specifier has the authority to approve a change in the base fineness modulus.

NOTE 7—The base fineness modulus should be determined from previous tests, or if no previous tests exist, from the average of the fineness modulus values for the first ten samples (or all preceding samples if less than ten) on the order. The proportioning of a concrete mixture may be dependent on the base fineness modulus of the fine aggregate to be used. Therefore, when it appears that the base fineness modulus is considerably different from the value used in the concrete mixture, a suitable adjustment in the mixture may be necessary.

7. Deleterious Substances

7.1 The amount of deleterious substances in fine aggregate shall not exceed the limits prescribed in Table 2.

7.2 *Organic Impurities:*

7.2.1 Fine aggregate shall be free of injurious amounts of organic impurities. Except as herein provided, aggregates subjected to the test for organic impurities and producing a color darker than the standard shall be rejected.

[6] *Significance of Tests and Properties of Concrete and Concrete Making Materials, STP 169D*, ASTM, 2006.

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TABLE 3 Grading Requirements for Coarse Aggregates

Size Number	Nominal Size (Sieves with Square Openings)	Amounts Finer than Each Laboratory Sieve (Square-Openings), Mass Percent													
		100 mm (4 in.)	90 mm (3½ in.)	75 mm (3 in.)	63 mm (2½ in.)	50 mm (2 in.)	37.5 mm (1½ in.)	25.0 mm (1 in.)	19.0 mm (¾ in.)	12.5 mm (½ in.)	9.5 mm (⅜ in.)	4.75 mm (No. 4)	2.36 mm (No. 8)	1.18 mm (No. 16)	300 µm (No.50)
1	90 to 37.5 mm (3½ to 1½ in.)	100	90 to 100	...	25 to 60	...	0 to 15	...	0 to 5	...	...	...	...	...	...
2	63 to 37.5 mm (2½ to 1½ in.)	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...	...	...
3	50 to 25.0 mm (2 to 1 in.)	...	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...	...
357	50 to 4.75 mm (2 in. to No. 4)	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	...	0 to 5	...	...	...
4	37.5 to 19.0 mm (1½ to ¾ in.)	...	...	...	...	100	90 to 100	20 to 55	0 to 15	...	0 to 5	...	...	...	...
467	37.5 to 4.75 mm (1½ in. to No. 4)	...	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	0 to 5	...	...	...
5	25.0 to 12.5 mm (1 to ½ in.)	...	...	...	...	...	100	90 to 100	20 to 55	0 to 10	0 to 5	...	...	...	...
56	25.0 to 9.5 mm (1 to ⅜ in.)	...	...	...	...	...	100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5	...	...	...
57	25.0 to 4.75 mm (1 in. to No. 4)	...	...	...	...	...	100	95 to 100	...	25 to 60	...	0 to 10	0 to 5	...	...
6	19.0 to 9.5 mm (¾ to ⅜ in.)	...	...	...	...	...	...	100	90 to 100	20 to 55	0 to 15	0 to 5	...	...	...
67	19.0 to 4.75 mm (¾ in. to No. 4)	...	...	...	...	...	...	100	90 to 100	...	20 to 55	0 to 10	0 to 5	...	...
7	12.5 to 4.75 mm (½ in. to No. 4)	...	...	...	...	...	...	...	100	90 to 100	40 to 70	0 to 15	0 to 5	...	...
8	9.5 to 2.36 mm (⅜ in. to No. 8)	...	...	...	...	...	...	...	...	100	85 to 100	10 to 30	0 to 10	0 to 5	...
89	9.5 to 1.18 mm (⅜ in. to No. 16)	...	...	...	...	...	...	...	...	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5
9[A]	4.75 to 1.18 mm (No. 4 to No. 16)	...	...	...	...	...	...	...	...	...	100	85 to 100	10 to 40	0 to 10	0 to 5

[A] Size number 9 aggregate is defined in Terminology C125 as a fine aggregate. It is included as a coarse aggregate when it is combined with a size number 8 material to create a size number 89, which is a coarse aggregate as defined by Terminology C125.

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TABLE 4 Limits for Deleterious Substances and Physical Property Requirements of Coarse Aggregate for Concrete

NOTE 1—See Fig. 1 for the location of the weathering regions and Note 12 for guidance in using the map. The weathering regions are defined as follows:
(S) Severe Weathering Region—A cold climate where concrete is exposed to deicing chemicals or other aggressive agents, or where concrete may become saturated by continued contact with moisture or free water prior to repeated freezing and thawing.
(M) Moderate Weathering Region—A climate where occasional freezing is expected, but where concrete in outdoor service will not be continually exposed to freezing and thawing in the presence of moisture or to deicing chemicals.
(N) Negligible Weathering Region—A climate where concrete is rarely exposed to freezing in the presence of moisture.

Class Designation	Type or Location of Concrete Construction	Maximum Allowable, %						
		Clay Lumps and Friable Particles	Chert (Less Than 2.40 sp gr SSD)	Sum of Clay Lumps, Friable Particles, and Chert (Less Than 2.40 sp gr SSD)	Material Finer Than 75-µm (No. 200) Sieve	Coal and Lignite	Abrasion[A]	Magnesium Sulfate Soundness (5 cycles)[B]
			Severe Weathering Regions					
1S	Footings, foundations, columns and beams not exposed to the weather, interior floor slabs to be given coverings	10.0	...	...	1.0[C]	1.0	50	...
2S	Interior floors without coverings	5.0	...	...	1.0[C]	0.5	50	...
3S	Foundation walls above grade, retaining walls, abutments, piers, girders, and beams exposed to the weather	5.0	5.0	7.0	1.0[C]	0.5	50	18
4S	Pavements, bridge decks, driveways and curbs, walks, patios, garage floors, exposed floors and porches, or waterfront structures, subject to frequent wetting	3.0	5.0	5.0	1.0[C]	0.5	50	18
5S	Exposed architectural or decorative concrete	2.0	3.0	3.0	1.0[C]	0.5	50	18
			Moderate Weathering Regions					
1M	Footings, foundations, columns, and beams not exposed to the weather, interior floor slabs to be given coverings	10.0	...	...	1.0[C]	1.0	50	...
2M	Interior floors without coverings	5.0	...	...	1.0[C]	0.5	50	...
3M	Foundation walls above grade, retaining walls, abutments, piers, girders, and beams exposed to the weather	5.0	8.0	10.0	1.0[C]	0.5	50	18
4M	Pavements, bridge decks, driveways and curbs, walks, patios, garage floors, exposed floors and porches, or waterfront structures subject to frequent wetting	5.0	5.0	7.0	1.0[C]	0.5	50	18
5M	Exposed architectural or decorative concrete	3.0	3.0	5.0	1.0[C]	0.5	50	18
			Negligible Weathering Regions					
1N	Slabs subject to traffic abrasion, bridge decks, floors, sidewalks, pavements	5.0	...	...	1.0[C]	0.5	50	...
2N	All other classes of concrete	10.0	...	...	1.0[C]	1.0	50	...

[A] Crushed air-cooled blast-furnace slag is excluded from the abrasion requirements. The rodded or jigged bulk density (unit weight) of crushed air-cooled blast-furnace slag shall be not less than 1120 kg/m^3 [70 lb/ft^3]. The grading of slag used in the bulk density (unit weight) test shall conform to the grading to be used in the concrete. Abrasion loss of gravel, crushed gravel, or crushed stone shall be determined on the test size or sizes most nearly corresponding to the grading or gradings to be used in the concrete. When more than one grading is to be used, the limit on abrasion loss shall apply to each.
[B] The allowable limits for soundness shall be 12 % if sodium sulfate is used.
[C] This percentage under either of the following conditions: (*1*) is permitted to be increased to 1.5 if the material is essentially free of clay or shale; or (*2*) if the source of the fine aggregate to be used in the concrete is known to contain less than the specified maximum amount passing the 75-µm (No. 200) sieve Table 1 the percentage limit (L) on the amount in the coarse aggregate is permitted to be increased to $L = 1 + [(P)/(100 - P)](T - A)$, where P = percentage of sand in the concrete as a percent of total aggregate, T = the Table 1 limit for the amount permitted in the fine aggregate, and A = the actual amount in the fine aggregate. (This provides a weighted calculation designed to limit the maximum mass of material passing the 75-µm (No. 200) sieve in the concrete to that which would be obtained if both the fine and coarse aggregate were supplied at the maximum tabulated percentage for each of these ingredients.)

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7.2.2 Use of a fine aggregate failing in the test is not prohibited, provided that the discoloration is due principally to the presence of small quantities of coal, lignite, or similar discrete particles.

7.2.3 Use of a fine aggregate failing in the test is not prohibited, provided that, when tested for the effect of organic impurities on strength of mortar, the relative strength at 7 days, calculated in accordance with Test Method C87/C87M, is not less than 95 %.

7.3 When required by the purchaser, fine aggregate for use in concrete shall be tested to determine the potential for deleterious alkali-aggregate reaction (see Note 8).

NOTE 8—Guide C1778 provides information on identifying and preventing the potential for deleterious alkali-aggregate reaction. Consideration is given to concrete mixture proportions, exposure conditions, and risk level.

8. Soundness

8.1 Except as provided in 8.2 and 8.3, fine aggregate subjected to five cycles of the soundness test shall have a weighted average loss not greater than 10 % when sodium sulfate is used or 15 % when magnesium sulfate is used.

8.2 Fine aggregate failing to meet the requirements of 8.1 shall be regarded as meeting the requirements of this section provided that the supplier demonstrates to the purchaser or specifier that concrete of comparable properties, made from similar aggregate from the same source, has given satisfactory service when exposed to weathering similar to that to be encountered.

8.3 Fine aggregate not having a demonstrable service record and failing to meet the requirements of 8.1 shall be regarded as meeting the requirements of this section provided that the supplier demonstrates to the purchaser or specifier it gives satisfactory results in concrete subjected to freezing and thawing tests (see Test Method C666/C666M).

COARSE AGGREGATE

9. General Characteristics

9.1 Coarse aggregate shall consist of gravel, crushed gravel, crushed stone, air-cooled blast furnace slag, or crushed hydraulic-cement concrete (see Note 9), or other recycled aggregate (see Note 2), or a combination thereof, conforming to the requirements of this specification.

NOTE 9—Although crushed hydraulic-cement concrete has been used as an aggregate with reported satisfactory results, its use may require some additional precautions. Mixing water requirements may be increased because of the harshness of the aggregate. Partially deteriorated concrete, used as aggregate, may reduce freeze-thaw resistance, affect air void properties or degrade during handling, mixing, or placing. Crushed concrete may have constituents that would be susceptible to alkali-aggregate reactivity or sulfate attack in the new concrete or may bring sulfates, chlorides, or organic material to the new concrete in its pore structure.

10. Grading

10.1 Coarse aggregates shall conform to the requirements prescribed in Table 3 for the size number specified.

NOTE 10—The ranges shown in Table 3 are by necessity very wide in order to accommodate nationwide conditions. For quality control of any specific operation, a producer should develop an average grading for the particular source and production facilities, and should control the production gradings within reasonable tolerances from this average. Where coarse aggregate size numbers 357 or 467 are used, the aggregate should be furnished in at least two separate sizes.

11. Deleterious Substances

11.1 Except for the provisions of 11.3, the limits given in Table 4 shall apply for the class of coarse aggregate designated in the purchase order or other document (see Note 11 and Note 12). If the class is not specified, the requirements for Class 3S, 3M, or 1N shall apply in the severe, moderate, and negligible weathering regions, respectively (see Table 4 and Fig. 1).

NOTE 11—The specifier of the aggregate should designate the class of coarse aggregate to be used in the work, based on weathering severity, abrasion, and other factors of exposure (see Table 4 and Fig. 1) . The limits for coarse aggregate corresponding to each class designation are expected to ensure satisfactory performance in concrete for the respective type and location of construction. Selecting a class with unduly restrictive limits may result in unnecessary cost if materials meeting those requirements are not locally available. Selecting a class with lenient limits may result in unsatisfactory performance and premature deterioration of the concrete. While concrete in different parts of a single structure may be adequately made with different classes of coarse aggregate, the specifier may wish to require the coarse aggregate for all concrete to conform to the same more restrictive class to reduce the chance of furnishing concrete with the wrong class of aggregate, especially on smaller projects.

NOTE 12—For coarse aggregate in concrete exposed to weathering, the map with the weathering regions shown in Fig. 1 is intended to serve only as a guide to probable weathering severity. Those undertaking construction, especially near the boundaries of weathering regions, should consult local weather bureau records for amount of winter precipitation and number of freeze-thaw cycles to be expected, for determining the weathering severity for establishing test requirements of the coarse aggregate. For construction at altitudes exceeding 1520 m [5000 ft] above sea level, the likelihood of more severe weathering than indicated by the map should be considered. In arid areas, severity of weathering may be less than that indicated. In either case, the definitions of weathering severity in Table 4 would govern. If there is doubt in choosing between two regions, select the more severe weathering region.

11.2 When required by the purchaser, coarse aggregate for use in concrete shall be tested to determine the potential for deleterious alkali-aggregate reaction (see Note 8).

11.3 Coarse aggregate having test results exceeding the limits specified in Table 4 shall be regarded as meeting the requirements of this section provided the supplier demonstrates to the purchaser or specifier that concrete made with similar aggregate from the same source has given satisfactory service when exposed in a similar manner to that to be encountered; or, in the absence of a demonstrable service record, provided that the aggregate produces concrete having satisfactory relevant properties (see Note 6).

METHODS OF SAMPLING AND TESTING

12. Methods of Sampling and Testing

12.1 Sample and test the aggregates in accordance with the following methods, except as otherwise provided in this specification. Make the required tests on test specimens that comply with requirements of the designated test methods. It is not prohibited to use the same test specimen for sieve analysis and for determination of material finer than the 75-µm (No.

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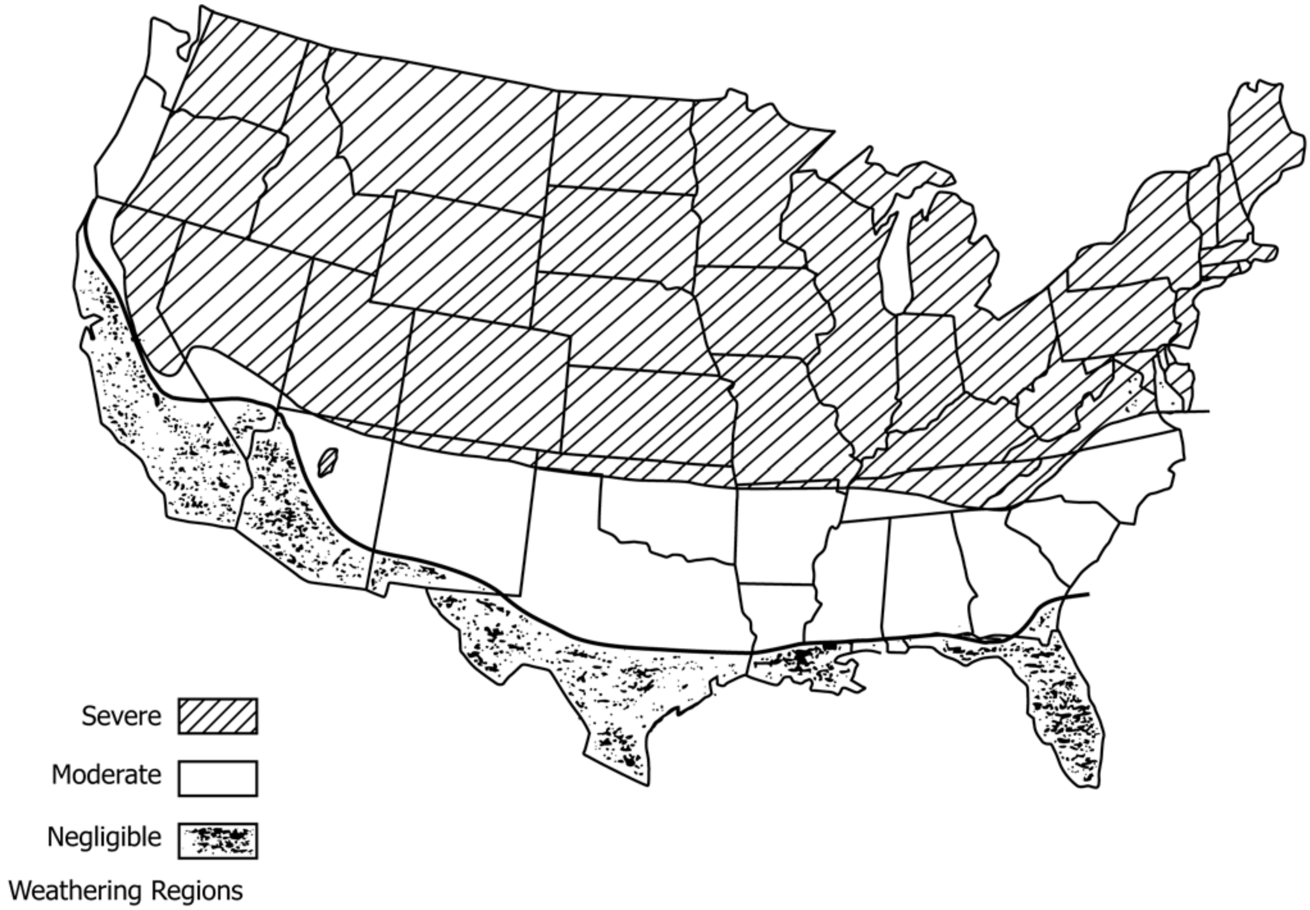

FIG. 1 Location of Weathering Regions

200) sieve. The use of separated sizes from the sieve analysis is acceptable for soundness or abrasion tests, however, additional test specimen preparation is required (see Note 13). For other test procedures and the evaluation of potential alkali reactivity, when required, use independent test specimens.

NOTE 13—The material used for the soundness test requires resieving to allow proper test specimen preparation as specified in Test Method C88.

12.1.1 *Sampling*—Practice D75/D75M and Practice D3665.

12.1.2 *Grading and Fineness Modulus*—Test Method C136/C136M.

12.1.3 *Amount of Material Finer than 75-µm (No. 200) Sieve*—Test Method C117.

12.1.4 *Organic Impurities*—Test Method C40/C40M.

12.1.5 *Effect of Organic Impurities on Strength*—Test Method C87/C87M.

12.1.6 *Soundness*—Test Method C88.

12.1.7 *Clay Lumps and Friable Particles*— Test Method C142/C142M.

12.1.8 *Coal and Lignite*—Test Method C123/C123M, using a liquid of 2.0 specific gravity to remove the particles of coal and lignite. Only material that is brownish-black, or black, shall be considered coal or lignite. Coke shall not be classed as coal or lignite.

12.1.9 *Bulk Density (Unit Weight) of Slag*—Test Method C29/C29M.

12.1.10 *Abrasion of Coarse Aggregate*—Test Method C131/C131M or Test Method C535.

12.1.11 *Alkali Aggregate Reactivity*—See Guide C1778.

12.1.12 *Freezing and Thawing*—Procedures for making freezing and thawing tests of concrete are described in Test Method C666/C666M.

12.1.13 *Chert*—Test Method C123/C123M is used to identify particles in a sample of coarse aggregate lighter than 2.40 specific gravity, and Guide C295/C295M to identify which of the particles in the light fraction are chert.

13. Keywords

13.1 aggregates; coarse aggregate; concrete aggregates; fine aggregate

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REFERENCES

(1) Ahn, N. and Fowler, D. W., "An Experimental Study on the Guidelines for Using Higher Contents of Aggregate Microfines in Portland Cement Concrete," ICAR Research Report 102-1F, International Center for Aggregates Research, University of Texas, Austin, TX, 2001, 435 pp. (http://www.icar.utexas.edu/publications/101_2F/101_2Cvr.pdf)

(2) Norvell, J.K., Stewart, J.G., Juenger, M.C.G and Fowler, D.W., "Influence of Clay and Clay-Sized Particles on Concrete Performance, "*Journal of Materials in Civil Engineering*, ASCE, Vol 19, No. 12, December 2007, pp. 1053–1059.

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this specification since the last issue, C33/C33M – $16^{\varepsilon 1}$, that may impact the use of this specification. (Approved March 15, 2018.)

(1) Revised Sections 4, 7, 11, and 12.

(2) Deleted Appendix X1.

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Designation: C78/C78M − 21

Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)[1]

This standard is issued under the fixed designation C78/C78M; 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 U.S. Department of Defense.

1. Scope*

1.1 This test method covers the determination of the flexural strength of concrete by the use of a simple beam with third-point loading.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field
C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
C42/C42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
C125 Terminology Relating to Concrete and Concrete Aggregates
C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
C293/C293M Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading)
C617/C617M Practice for Capping Cylindrical Concrete Specimens
C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
C1077 Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
E4 Practices for Force Verification of Testing Machines
E6 Terminology Relating to Methods of Mechanical Testing

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Terminology C125 and Terminology E6.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *flexural strength*—maximum resistance of a specimen subjected to bending.

3.2.1.1 *Discussion*—In this test method, *flexural strength* is reported as the *modulus of rupture*.

3.2.2 *flexural testing apparatus*—fixture used to apply force to the beam specimen and consists of loading and support blocks.

3.2.3 *loading block*—component of the testing apparatus in the shape of a portion of a cylinder that is used to apply a force to the beam specimen.

3.2.4 *modulus of rupture*—calculated stress, assuming linear-elastic behavior, in the tensile face of a beam specimen at the maximum bending moment during a standard test method.

3.2.5 *span length*—distance between lines of support, or reaction, for the beam specimen, and it is equal to three times the nominal depth of the beam.

3.2.5.1 *Discussion*—For example, for a 100 mm [4 in.]

[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 March 1, 2021. Published March 2021. Originally approved in 1930. Last previous edition approved in 2018 as C78/C78M – 18. DOI: 10.1520/C0078_C0078M-21.

[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

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nominal depth beam, the span length is 300 mm [12 in.] and for a 150 mm [6 in.] nominal depth beam, the span length is 450 mm [18 in.]. See 3.2.6.1, for discussion of *reaction block*.

3.2.6 *support block*—component of the testing apparatus in the shape of a portion of a cylinder that is used to provide a reaction to the force applied to the beam specimen.

3.2.6.1 *Discussion*—If the testing apparatus applies force to the top of the beam, this block supports the beam. If the testing apparatus applies force to the bottom of the beam, the support block may be considered a reaction block because it provides a line of reaction at the top of the beam and does not support the beam.

3.2.7 *testing machine*—mechanical device for applying force to a specimen.

4. Significance and Use

4.1 This test method is used to determine the flexural strength of specimens prepared and cured in accordance with Test Methods C42/C42M or Practices C31/C31M or C192/C192M. Results are calculated and reported as the modulus of rupture. For the same specimen size, the strength determined will vary if there are differences in specimen preparation, curing procedure, moisture condition at time of testing, and whether the beam was molded or sawed to size.

4.2 The measured modulus of rupture generally increases as the specimen size decreases.[3,4,5]

4.3 The results of this test method may be used to determine compliance with specifications or as a basis for mixture proportioning, evaluating uniformity of mixing, and checking placement operations by using sawed beams. It is used primarily in testing concrete for the construction of slabs and pavements.

4.4 For identical test specimens, the modulus of rupture obtained by this test method will, on average, be lower than that obtained by Test Method C293/C293M.

5. Apparatus

5.1 *Testing Machine*—Hand operated testing machines having pumps that do not provide a continuous loading in one stroke are not permitted. Motorized pumps or hand operated positive displacement pumps having sufficient volume in one continuous stroke to complete a test without requiring replenishment are permitted and shall be capable of applying loads at a uniform rate without shock or interruption. The testing machine shall be equipped with a means of recording or holding the peak value that will indicate the maximum load, to within 1 % accuracy, applied to the specimen during a test.

5.1.1 *Verification:*

5.1.1.1 The testing machine shall conform to the requirements of the sections on Basis of Verification, Corrections, and Time Interval Between Verifications of Practice E4.

5.1.1.2 Verify the accuracy of the testing machine in accordance with Practice E4, except that the verified loading range shall be as required for flexural testing. Verification is required:

(1) Within 13 months of the last verification,

(2) On original installation,

(3) After relocation,

(4) After making repairs or adjustments that affect the operation of the force applying system or the values displayed on the load indicator, except for zero adjustments that compensate for the weight of loading or support blocks or specimen, or both, or

(5) Whenever there is reason to suspect the accuracy of the indicated forces.

5.2 *Flexural Testing Apparatus*—The third point loading method shall be used to determine the flexural strength of concrete. The loading blocks and support blocks shall be designed so that forces applied to the beam will be along lines perpendicular to the side faces of the beam and applied without eccentricity. A diagram of the flexural testing apparatus is shown in Fig. 1.

NOTE 1—The flexural testing apparatus shown in Fig. 1 may be used inverted. In this case, the loading blocks will be at the bottom of the beam, while the reaction blocks will be at the top of the beam.

5.2.1 The flexural testing apparatus shall be capable of maintaining the span length and distance between the lines of loading within ±1.0 mm [±0.05 in.] of the specified values.

5.2.2 The ratio of the horizontal distance between the line of application of the force and the line of the nearest reaction to the depth of the beam shall be 1.0 ± 0.03.

5.2.3 The loading blocks and support blocks shall not be more than 65 mm [2.50 in.] high, measured from the center or the axis of the ball or the axis of the rod and shall extend entirely across or beyond the full width of the specimen. Each case, the block surface in contact with the specimen shall not depart from a plane by more than 0.05 mm [0.002 in.] and shall be a portion of a cylinder, the axis of which is coincidental with either the axis of the rod or center of the ball, whichever the block is pivoted upon. The angle subtended by the curved surface of each block shall be at least 0.80 rad [45°].

5.2.4 At least every six months or as specified by the manufacturer of the flexural testing apparatus, clean and lubricate metal-to-metal contact surfaces, such as internal concave surfaces and steel balls and rods of the loading blocks and support blocks (Fig. 1). The lubricant shall be a petroleum-type oil, such as conventional motor oil, or as specified by the manufacturer of the apparatus.

5.2.5 The support blocks shall be free to rotate.

5.2.6 The loading blocks and support blocks shall be maintained in a vertical position and in contact with the rod or ball by means of spring-loaded screws that hold them in contact with the rod or ball. The uppermost bearing plate and center point ball in Fig. 1 may be omitted if the testing machine

[3] Tanesi, J; Ardani, A. Leavitt, J. "Reducing the Specimen Size of Concrete Flexural Strength Test (AASHTO T97) for Safety and Ease of Handling," *Transportation Research Record: Journal of the Transportation Research Board*, No. 2342, Transportation Research Board of National Academies, Washington, D.C., 2013.

[4] Carrasquillo, P.M. and Carrasquillo, R. L "Improved Concrete Quality Control Procedures Using Third Point Loading", *Research Report 119-1F*, Project 3-9-87-1119, Center For Transportation Research, The University of Texas at Austin, November 1987.

[5] Bazant, Z. and Novak, D. "Proposal for Standard Test of Modulus of Rupture of Concrete with its Size Dependence," *ACI Materials Journal*, January-February 2001.

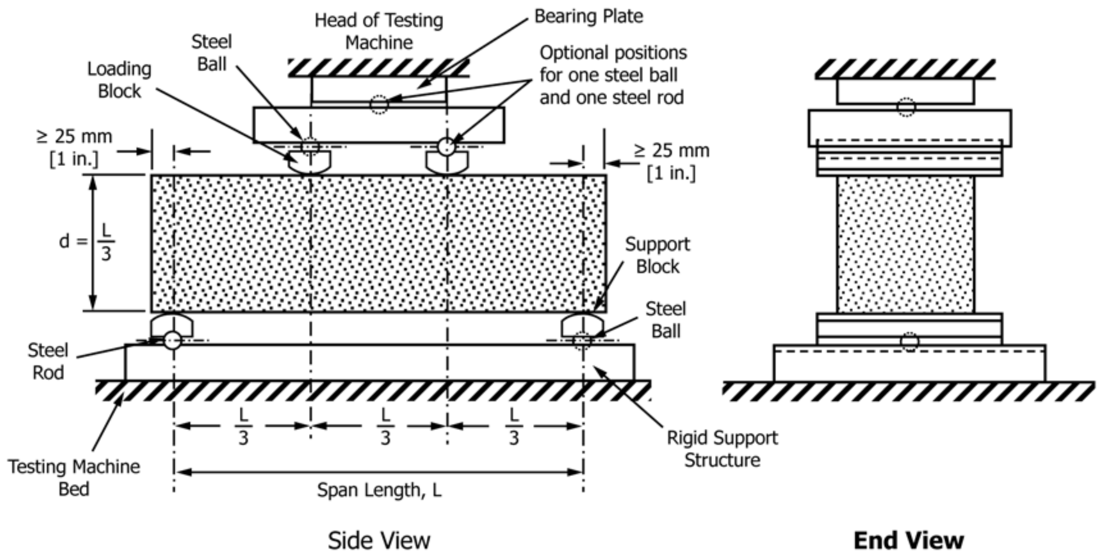

FIG. 1 Schematic of Flexural Testing Apparatus for Third-Point Loading Method

has a spherically seated bearing block that meets the requirements of Test Method C39/C39M, provided one rod and one ball are used as pivots for the upper loading blocks.

6. Test Specimens

6.1 The test specimen shall conform to all requirements of Test Method C42/C42M or Practices C31/C31M or C192/C192M applicable to beam specimens and shall have a test span within 2 % of being three times its depth as tested. The sides of the specimen shall be at right angles with the top and bottom. All surfaces shall be smooth and free of scars, indentations, holes, or inscribed identification marks.

6.2 Provided the smaller cross-sectional dimension of the beam is at least three times the nominal maximum size of the coarse aggregate, the modulus of rupture can be determined using different specimen sizes. However, measured modulus of rupture generally increases as specimen size decreases.[3,4] (Note 2).

NOTE 2—The strength ratio for beams of different sizes depends primarily on the maximum size of aggregate.[5] Experimental data obtained in two different studies have shown that for maximum aggregate size between 19.0 mm and 25.0 mm [¾ in. and 1 in.], the ratio between the modulus of rupture determined with a 150 mm by 150 mm [6 in. by 6 in.] and a 100 mm by 100 mm [4 in. by 4 in.] may vary from 0.90 to 1.07[3] and for maximum aggregate size between 9.5 mm and 37.5 mm [⅜ in. and 1½ in.], the ratio between the modulus of rupture determined with a 150 mm by 150 mm [6 in. by 6 in.] and a 115 mm by 115 mm [4.5 in. by 4.5 in.] may vary from 0.86 to 1.00.[4]

6.3 The specifier of tests shall specify the specimen size and number of specimens to be tested to obtain an average test result. The same specimen size shall be used for qualification and acceptance testing.

7. Procedure

7.1 Moist-cured specimens shall be kept moist during the period between removal from moist storage and testing.

NOTE 3—Surface drying of the specimen results in a reduction in the measured flexural strength.

NOTE 4—Methods for keeping the specimen moist include wrapping in moist fabric or matting and keeping specimens under lime water in containers near the flexural testing machine until time of testing.

7.2 For molded specimens, turn the test specimen on its side with respect to its position as molded and center it on the support blocks. When using sawed specimens, position the specimen so that the tension face corresponds to the top or bottom of the specimen as cut from the parent material. Center the loading blocks in relation to the applied force. Bring the loading blocks in contact with the surface of the specimen at the third points and apply a force of between 3 and 6 % of the estimated ultimate force. Using 0.10 mm [0.004 in.] and 0.40 mm [0.015 in.] leaf-type feeler gages, determine whether any gap between the specimen and the loading or support blocks is greater or less than each of the gages over a length of 25 mm [1 in.] or more. Grind, cap, or use leather shims on the specimen contact surface to eliminate any gap in excess of 0.10 mm [0.004 in.] in width. Leather shims shall be of uniform 6 mm [0.25 in.] thickness, 25 mm to 50 mm [1.0 in. to 2.0 in.] width, and shall extend across the full width of the specimen. Gaps in excess of 0.40 mm [0.015 in.] shall be eliminated only by capping or grinding. Grinding of lateral surfaces shall be minimized because grinding may change the physical characteristics of the specimens. Capping shall be in accordance with the applicable sections of Practice C617/C617M.

7.3 Load the specimen continuously and without shock. The load shall be applied at a constant rate to the breaking point. Apply the load at a rate that constantly increases the maximum stress on the tension face between 0.9 MPa/min and 1.2 MPa/min [125 psi/min and 175 psi/min] until rupture occurs. The loading rate is calculated using the following equation:

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$$r = \frac{Sbd^2}{L} \quad (1)$$

where:

r = loading rate, N/min [lb/min],
S = rate of increase in maximum stress on the tension face, MPa/min [psi/min],
b = average width of the specimen as oriented for testing, mm [in.],
d = average depth of the specimen as oriented for testing, mm [in.], and
L = span length, mm [in.].

8. Measurement of Specimens After Test

8.1 To determine the dimensions of the specimen cross section for use in calculating modulus of rupture, take measurements across one of the fractured faces after testing. The width and depth are measured with the specimen as oriented for testing. For each dimension, take one measurement at each edge and one at the center of the cross section. Use the three measurements for each direction to determine the average width and the average depth. Take all measurements to the nearest 1 mm [0.05 in.]. If the fracture occurs at a capped section, include the cap thickness in the measurement.

9. Calculation

9.1 If the fracture initiates in the tension surface within the middle third of the span length, calculate the modulus of rupture as follows:

$$R = \frac{PL}{bd^2} \quad (2)$$

where:

R = modulus of rupture, MPa [psi],
P = maximum applied load indicated by the testing machine, N [lbf],
L = span length, mm [in.],
b = average width of specimen, mm [in.], at the fracture, and
d = average depth of specimen, mm [in.], at the fracture.

NOTE 5—The weight of the beam is not included in the above calculation.

9.2 If the fracture occurs in the tension surface outside of the middle third of the span length by not more than 5 % of the span length, calculate the modulus of rupture as follows:

$$R = \frac{3Pa}{bd^2} \quad (3)$$

where:

a = average distance between line of fracture and the nearest support measured on the tension surface of the beam, mm [in.].

NOTE 6—The weight of the beam is not included in the above calculation.

9.3 If the fracture occurs in the tension surface outside of the middle third of the span length by more than 5 % of the span length, discard the results of the test.

10. Report

10.1 Report the following information:
10.1.1 Identification number,
10.1.2 Average width to the nearest 1 mm [0.05 in.],
10.1.3 Average depth to the nearest 1 mm [0.05 in.],
10.1.4 Span length in mm [in.],
10.1.5 Maximum applied load in N [lbf],
10.1.6 Modulus of rupture calculated to the nearest 0.05 MPa [5 psi],
10.1.7 Curing history and apparent moisture condition of the specimens at the time of test,
10.1.8 If specimens were capped, ground, or if leather shims were used,
10.1.9 Whether sawed or molded and defects in specimens, and
10.1.10 Age of specimens.

11. Precision and Bias

11.1 *Precision:*

11.1.1 *Single-Operator Precision*—The single operator standard deviation for test determinations has been found to be 0.25 MPa [37 psi] and to be independent of the beam sizes used in the interlaboratory study (ILS) (Note 7). Therefore, the modulus of rupture from two properly conducted tests by the same operator on specimens of the same material (same batch of concrete), using the same size specimen (100 mm [4 in.] or 150 mm [6 in.] deep beams), is not expected to differ by more than 0.72 MPa [104 psi].[6]

11.1.2 *Multi-Laboratory Precision*—The multilaboratory coefficient of variation for test determinations has been found to be as shown in the third column of Table 1. The coefficient of variation was found to be similar for both specimen sizes used in the ILS for modulus of rupture between 4.2 MPa and 5.5 MPa [600 psi and 800 psi]. A higher multilaboratory coefficient of variation was observed for 100 mm [4 in.] deep beams for modulus of rupture near 6.9 MPa [1000 psi]. Therefore, the modulus of rupture from two properly conducted tests by two different laboratories on specimens of the same material (same batch of concrete) and beam size are not

[6] This number represents the difference limit (d2s) as described in Practice C670.

TABLE 1 Multilaboratory Precision

Beam Depth, in. [mm]	Modulus of Rupture, psi [MPa]	Coefficient of Variation	Acceptable Difference Between Two Test Determinations (percentage of their average)[A]
100 mm [4 in.]	4.1 MPa to 5.5 MPa [600 psi to 800 psi]	6.1 %	17.1 %
100 mm [4 in.]	6.9 MPa [1000 psi]	11.4 %	31.8 %
150 mm [6 in.]	4.1 MPa to 6.9 MPa [600 psi to 1000 psi]	6.9 %	19.3 %

[A] These numbers represent the difference limit (d2s %) as described in Practice C670.

expected to differ from each other by more than the value in the fourth column of Table 1. The acceptable difference between two test determinations is expressed as a percentage of their average.

NOTE 7—The precision of this test method was determined from an interlaboratory study conducted in 2016. The study involved three concrete mixtures with modulus of rupture values of approximately 4.1 MPa [600 psi], 5.5 MPa [800 psi] and 6.9 MPa [1000 psi]. Two beam sizes were used: 100 mm by 100 mm by 355 mm [4 in. by 4 in. by 14 in.] and 150 mm by 150 mm by 533 mm [6 in. by 6 in. by 21 in.]. Three test determinations were conducted for each combination of specimen size and concrete mixture. The number of laboratories used for determining the precision varied from 10 to 17 depending on the concrete mixture and beam size. The data used to develop the precision statement were obtained using the inch-pound version of this test method. The precision indexes shown in SI units are exact conversions of the values in inch-pound units. Supporting data have been filed at ASTM Headquarters and may be obtained by requesting Research Report RR:C09-1050.[7]

[7] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1050. Contact ASTM Customer Service at service@astm.org.

NOTE 8—The results for each test condition (specimen size and concrete strength) include data from 3 to 5 laboratories that used hand operated testing machines with paper charts for reading the ultimate force. For the 100 mm [4 in.] deep beams, these machines resulted in higher single-operator variability in mixtures with strengths between 4.1 MPa to 5.5 MPa [600 psi and 800 psi], as well as higher multilaboratory variability in all mixtures. For the 150 mm [6 in.] deep beams, these machines resulted in higher variability only for the mixture with flexural strength of approximately 6.9 MPa [1000 psi]. Refer to Research Report RR:C09-1050 (Appendix J) for a discussion of possible reasons why these machines may have resulted in higher variability.

11.2 *Bias*—Because there is no accepted standard for determining bias in this test method, no statement on bias is made.

12. Keywords

12.1 beams; concrete; flexural strength testing; modulus of rupture

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this test method since the last issue, C78/C78M – 18, that may impact the use of this test method. (Approved March 1, 2021.)

(1) Section 5.2.6 was revised.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

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Designation: C39/C39M – 20

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 U.S. 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, health, and environmental 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 R0030 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.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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
C125 Terminology Relating to Concrete and Concrete Aggregates
C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
C617/C617M Practice for Capping Cylindrical Concrete Specimens
C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
C873/C873M Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds
C943 Practice for Making Test Cylinders and Prisms for Determining Strength and Density of Preplaced-Aggregate Concrete in the Laboratory
C1077 Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
C1176/C1176M Practice for Making Roller-Compacted Concrete in Cylinder Molds Using a Vibrating Table
C1231/C1231M Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Cylindrical Concrete Specimens
C1435/C1435M Practice for Molding Roller-Compacted Concrete in Cylinder Molds Using a Vibrating Hammer
C1604/C1604M Test Method for Obtaining and Testing Drilled Cores of Shotcrete
E4 Practices for Force Verification of Testing Machines
E18 Test Methods for Rockwell Hardness of Metallic Materials

[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 Feb. 1, 2020. Published March 2020. Originally approved in 1921. Last previous edition approved in 2018 as C39/C39M – 18. DOI: 10.1520/C0039_C0039M-20.

[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**

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E74 Practices for Calibration and Verification for Force-Measuring Instruments
R0030 Manual of Aggregate and Concrete Testing

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, refer to Terminology C125.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bearing block, n*—steel piece to distribute the load from the testing machine to the specimen.

3.2.2 *lower bearing block, n*—steel piece placed under the specimen to distribute the load from the testing machine to the specimen.

3.2.2.1 *Discussion*—The lower bearing block provides a readily machinable surface for maintaining the specified bearing surface. The lower bearing block may also be used to adapt the testing machine to various specimen heights. The lower bearing block is also referred to as *bottom block*, *plain block*, and *false platen*.

3.2.3 *platen, n*—primary bearing surface of the testing machine.

3.2.3.1 *Discussion*—The platen is also referred to as the testing machine *table*.

3.2.4 *spacer, n*—steel piece used to elevate the lower bearing block to accommodate test specimens of various heights.

3.2.4.1 *Discussion*—Spacers are not required to have hardened bearing faces because spacers are not in direct contact with the specimen or the retainers of unbonded caps.

3.2.5 *upper bearing block, n*—steel assembly suspended above the specimen that is capable of tilting to bear uniformly on the top of the specimen.

3.2.5.1 *Discussion*—The upper bearing block is also referred to as the *spherically seated block* and the *suspended block*.

4. Summary of Test Method

4.1 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.

5. Significance and Use

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

5.2 This test method is used to determine compressive strength of cylindrical specimens prepared and cured in accordance with Practices C31/C31M, C192/C192M, C617/C617M, C943, C1176/C1176M, C1231/C1231M, and C1435/C1435M, and Test Methods C42/C42M, C873/C873M, and C1604/C1604M.

5.3 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.

5.4 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.

6. Apparatus

6.1 *Testing Machine*—The testing machine shall be of a type having sufficient capacity and capable of providing the rates of loading prescribed in 8.5.

6.1.1 Verify the accuracy of the testing machine in accordance with Practices E4, except that the verified loading range shall be as required in 6.4. Verification is required:

6.1.1.1 Within 13 months of the last calibration,

6.1.1.2 On original installation or immediately after relocation,

6.1.1.3 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

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

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

6.1.2.1 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 8.5), 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.

6.1.2.2 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.

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

6.1.3.1 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.

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6.1.3.2 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.

6.1.3.3 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:

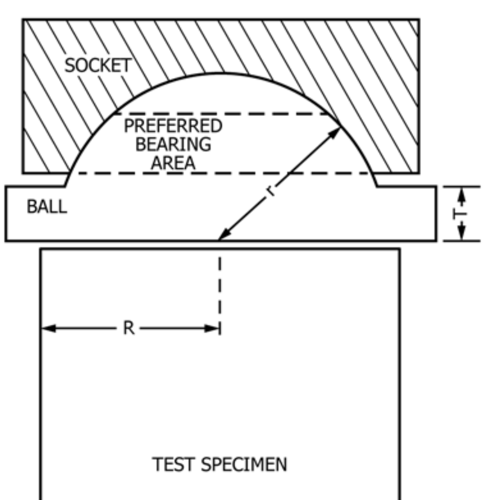
A = load, kN [lbf] indicated by the machine being verified, and

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

6.1.3.4 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.

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

6.1.3.6 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.



$T \geq R - r$

r = radius of spherical portion of upper bearing block

R = nominal radius of specimen

T = thickness of upper bearing block extending beyond the sphere

FIG. 1 Schematic Sketch of Typical Upper Bearing Block

6.2 *Bearing Blocks*—The upper and lower bearing blocks shall conform to the following requirements:

6.2.1 Bearing blocks shall be steel with hardened bearing faces (Note 3).

6.2.2 Bearing faces shall have dimensions at least 3 % greater than the nominal diameter of the specimen.

6.2.3 Except for the inscribed concentric circles described in 6.2.4.7, the bearing faces shall not depart from a plane by more than 0.02 mm [0.001 in.] along any 150 mm [6 in.] length for bearing blocks with a diameter of 150 mm [6 in.] or larger, or by more than 0.02 mm [0.001 in.] in any direction of smaller bearing blocks. New bearing blocks shall be manufactured within one half of this tolerance.

NOTE 3—It is desirable that the bearing faces of bearing blocks have a Rockwell hardness at least 55 HRC as determined by Test Methods E18.

NOTE 4—Square bearing faces are permissible for the bearing blocks.

6.2.4 *Upper Bearing Block*—The upper bearing block shall conform to the following requirements:

6.2.4.1 The upper bearing block shall be spherically seated and the center of the sphere shall coincide with the center of the bearing face within ±5 % of the radius of the sphere.

6.2.4.2 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 5—The preferred contact area is in the form of a ring (described as *preferred bearing area*) as shown in Fig. 1.

6.2.4.3 Provision shall be made for holding the upper bearing block in the socket. The design shall be such that the bearing face can be rotated and tilted at least 4° in any direction.

6.2.4.4 If 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.

6.2.4.5 The diameter of the sphere shall be at least 75 % of the nominal diameter of the specimen. If the diameter of the sphere is smaller than the diameter of the specimen, 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 (see Fig. 1). The least dimension of the bearing face shall be at least as great as the diameter of the sphere.

6.2.4.6 The dimensions of the bearing face of the upper bearing block shall not exceed the following values:

Nominal Diameter of Specimen, mm [in.]	Maximum Diameter of Round Bearing Face, mm [in.]	Maximum Dimensions of Square Bearing Face, mm [in.]
50 [2]	105 [4]	105 by 105 [4 by 4]
75 [3]	130 [5]	130 by 130 [5 by 5]
100 [4]	165 [6.5]	165 by 165 [6.5 by 6.5]
150 [6]	255 [10]	255 by 255 [10 by 10]
200 [8]	280 [11]	280 by 280 [11 by 11]

6.2.4.7 If the diameter of the bearing face of the upper bearing block exceeds the nominal 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 on the face of upper bearing block to facilitate proper centering.

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6.2.4.8 At least every six months, or as specified by the manufacturer of the testing machine, clean and lubricate the curved surfaces of the socket and of the spherical portion of the upper bearing block. The lubricant shall be a petroleum-type oil such as conventional motor oil or as specified by the manufacturer of the testing machine.

NOTE 6—To ensure uniform seating, the upper bearing block is designed to tilt freely as it comes into contact with the top of the specimen. After contact, further rotation is undesirable. Friction between the socket and the spherical portion of the head provides restraint against further rotation during loading. Pressure-type greases can reduce the desired friction and permit undesired rotation of the spherical head and should not be used unless recommended by the manufacturer of the testing machine. Petroleum-type oil such as conventional motor oil has been shown to permit the necessary friction to develop.

6.2.5 *Lower Bearing Block*—The lower bearing block shall conform to the following requirements:

6.2.5.1 The lower bearing block shall be solid.

6.2.5.2 The top and bottom surfaces of the lower bearing block shall be parallel to each other.

6.2.5.3 The lower bearing block shall be at least 25 mm [1.0 in.] thick when new, and at least 22.5 mm [0.9 in.] thick after resurfacing.

6.2.5.4 The lower bearing block shall be fully supported by the platen of the testing machine or by any spacers used.

6.2.5.5 If the testing machine is designed that the platen itself is readily maintained in the specified surface condition, a lower bearing block is not required.

NOTE 7—The lower bearing block may be fastened to the platen of the testing machine.

NOTE 8—Inscribed concentric circles as described in 6.2.4.7 are optional on the lower bearing block.

6.3 *Spacers*—If spacers are used, the spacers shall be placed under the lower bearing block and shall conform to the following requirements:

6.3.1 Spacers shall be solid steel. One vertical opening located in the center of the spacer is permissible. The maximum diameter of the vertical opening is 19 mm [0.75 in.].

6.3.2 The top and bottom surfaces of the spacer shall be parallel to each other.

6.3.3 Spacers shall be fully supported by the platen of the test machine.

6.3.4 Spacers shall fully support the lower bearing block and any spacers above.

6.3.5 Spacers shall not be in direct contact with the specimen or the retainers of unbonded caps.

6.4 *Load Indication*—The testing machine shall be equipped with either a dial or digital load indicator.

6.4.1 The verified loading range shall not include loads less than 100 times the smallest change of load that can be read.

6.4.2 A means shall be provided that will record, or indicate until reset, the maximum load to an accuracy within 1.0 % of the load.

6.4.3 If the load is displayed on a dial, the graduated scale shall be readable to at least the nearest 0.1 % of the full scale load (Note 9). The dial shall be readable within 1.0 % of the indicated load at any given load level within the loading range. 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. The scale shall be provided with a labeled graduation line load corresponding to zero load. Each dial shall be equipped with a zero adjustment located outside the dial case and accessible from the front of the machine while observing the zero mark and dial pointer.

NOTE 9—Readability is considered to be 0.5 mm [0.02 in.] along the arc described by the end of the pointer. If the spacing is between 1 and 2 mm [0.04 and 0.08 in.], one half of a scale interval is considered readable. If the spacing is between 2 and 3 mm [0.08 and 0.12 in.], one third of a scale interval is considered readable. If the spacing is 3 mm [0.12 in.] or more, one fourth of a scale interval is considered readable.

6.4.4 If the load is displayed in digital form, the numbers must be large enough to be read. The numerical increment shall not exceed 0.1 % of the full scale load of a given loading range. Provision shall be made for adjusting the display to indicate a value of zero when no load is applied to the specimen.

6.5 Documentation of the calibration and maintenance of the testing machine shall be in accordance with Practice C1077.

7. Specimens

7.1 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 10—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.

7.2 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/C617M 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.

7.3 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.

7.4 If the purchaser of the testing services or the specifier of the tests requests measurement of the specimen density, determine the specimen density before capping by either 7.4.1

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(specimen dimension method) or 7.4.2 (submerged weighing method). For either method, use a balance or scale that is accurate to within 0.3 % of the mass being measured.

7.4.1 Remove any surface moisture with a towel and measure the mass of the specimen. 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.].

7.4.2 Remove any surface moisture with a towel and determine the mass of the specimen in air. Submerge the specimen in water at a temperature of 23.0 ± 2.0°C [73.5 ± 3.5°F] for 15 ± 5 sec. Then, determine the apparent mass of the specimen while submerged under water.

7.5 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.

8. Procedure

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

8.2 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.

8.3 Tolerances for specimen ages are as follows:

Test Age[A]	Permissible Tolerance
24 h	±0.5 h
3 days	±2 h
7 days	±6 h
28 days	±20 h
90 days	±2 days

[A]For test ages not listed, the test age tolerance is ±2.0% of the specified age.

8.3.1 Unless otherwise specified by the specifier of tests, for this test method the test age shall start at the beginning of casting specimens.

8.4 *Placing the Specimen*—Place the lower bearing block, with the hardened face up, on the table or platen of the testing machine. Wipe clean the bearing faces of the upper and lower bearing blocks, spacers if used, and of the specimen. If using unbonded caps, wipe clean the bearing surfaces of the retainers and center the unbonded caps on the specimen. Place the specimen on the lower bearing block and align the axis of the specimen with the center of thrust of the upper bearing block.

NOTE 11—Although the lower bearing block may have inscribed concentric circles to assist with centering the specimen, final alignment is made with reference to the upper bearing block.

8.4.1 *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 12). 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 12—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.

8.4.2 *Verification of Alignment When Using Unbonded Caps*—If using unbonded caps, verify the alignment of the specimen after application of load, but before reaching 10 % of the anticipated specimen strength. Check to see that the axis of the cylinder does not depart from vertical by more than 0.5° (Note 13) and that the ends of the cylinder are centered within the retaining rings. If the cylinder alignment does not meet these requirements, release the load, and carefully recenter the specimen. Reapply load and recheck specimen centering and alignment. A pause in load application to check cylinder alignment is permissible.

NOTE 13—An angle of 0.5° is equal to a slope of approximately 1 mm in 100 mm [⅛ inches in 12 inches]

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

8.5.1 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 14). The designated rate of movement shall be maintained at least during the latter half of the anticipated loading phase.

NOTE 14—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.

8.5.2 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.

8.5.3 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.

8.6 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/C617M or Practice C1231/C1231M.

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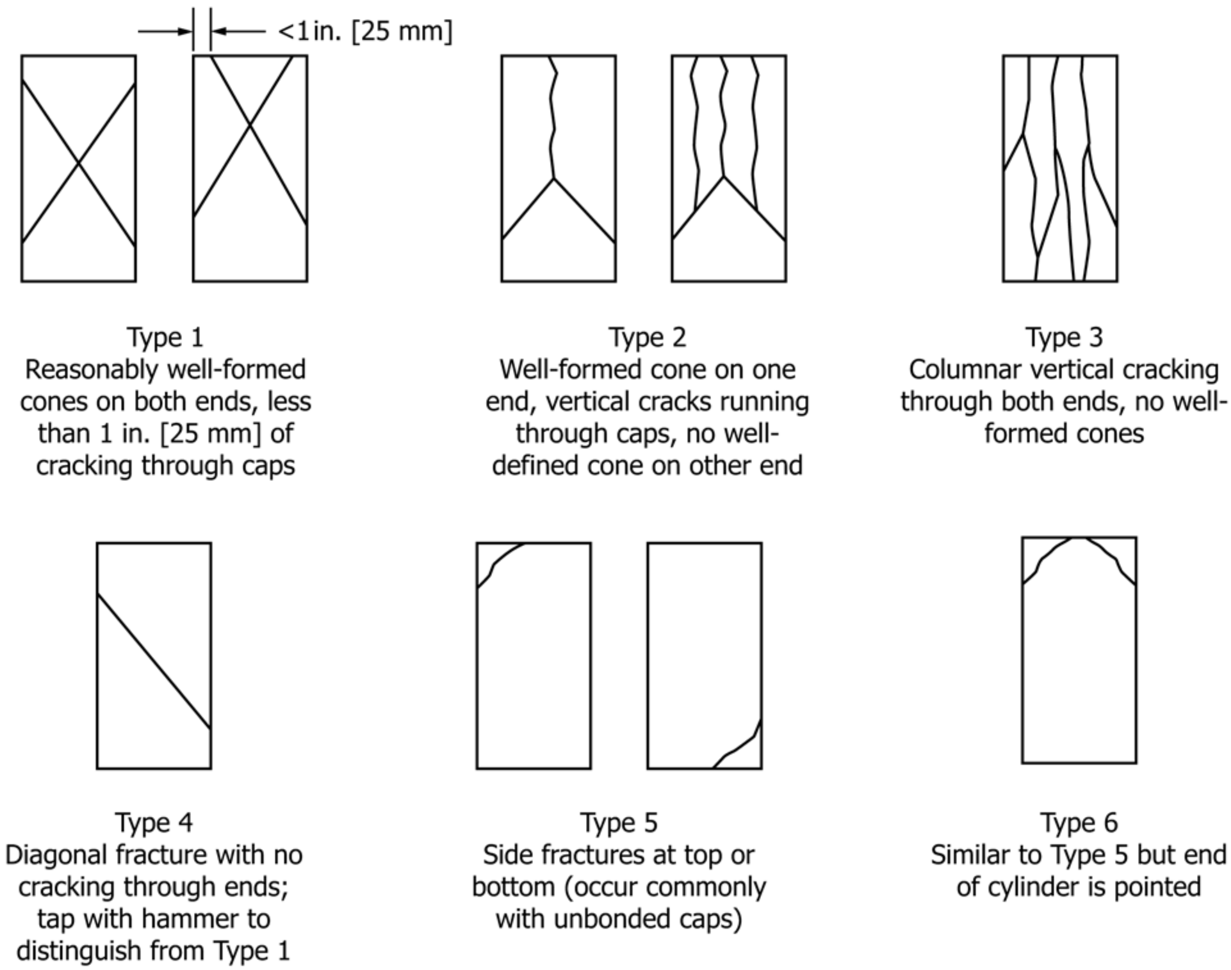

FIG. 2 Schematic of Typical Fracture Patterns

9. Calculation

9.1 Calculate the compressive strength of the specimen as follows:

SI units:

$$f_{cm} = \frac{4000 P_{max}}{\pi D^2} \quad (2)$$

Inch-pound units:

$$f_{cm} = \frac{4 P_{max}}{\pi D^2} \quad (3)$$

where:

f_{cm} = compressive strength, MPa [psi],
P_{max} = maximum load, kN [lbf], and
D = average measured diameter, mm [in.].

Use at least five digits for the value of π, that is, use 3.1416 or a more precise value.

9.2 If the specimen length to diameter ratio is 1.75 or less, correct the result obtained in 9.1 by multiplying by the appropriate correction factor shown in the following table:

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 15—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 MPa [6000 psi] correction factors may be larger than the values listed above[3].

9.3 If required, calculate the specimen density to the nearest 10 kg/m^3 [1 lb/ft^3] using the applicable method.

9.3.1 If specimen density is determined based on specimen dimensions, calculate specimen density as follows:

SI units:

$$\rho_s = \frac{4 \times 10^9 \times W}{L \times D^2 \times \pi} \quad (4)$$

Inch-pound units:

$$\left[\rho_s = \frac{6912 \times W}{L \times D^2 \times \pi} \right] \quad (5)$$

where:

ρ_s = specimen density, kg/m^3 [lb/ft^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.

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W = mass of specimen in air, kg [lb],
L = average measured length, mm [in.], and
D = average measured diameter, mm [in.].

9.3.2 If the specimen density is based on submerged weighing, calculate the specimen density as follows:

$$\rho_s = \frac{W \times \gamma_w}{W - W_s} \quad (6)$$

where:

ρ_s = specimen density, kg/m^3 [lb/ft^3],
W = mass of specimen in air, kg [lb],
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 lb/ft^3].

10. Report

10.1 Report the following information:

10.1.1 Identification number,

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

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

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

10.1.5 Compressive strength rounded to the nearest 0.1 MPa [10 psi],

10.1.6 If the average of two or more companion cylinders tested at the same age is reported, calculate the average compressive strength using the unrounded individual compressive strength values. Report the average compressive-strength rounded to the nearest 0.1 MPa [10 psi].

10.1.7 Type of fracture (see Fig. 2),

10.1.8 Defects in either specimen or caps,

10.1.9 Age of specimen at time of testing. Report age in days for ages three days or greater, report age in hours if the age is less than three days,

NOTE 16—If software limitations prevent reporting the specimen age in hours, the age of the specimen in hours may be included in a note in the report.

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

11. Precision and Bias

11.1 *Precision*

11.1.1 *Single-Operator Precision*—The following table provides the single-operator 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 11.1.2).

	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 %

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

11.1.2 The single-operator 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 single-operator coefficient of variation of 150 by 300 mm [6 by 12 in.] cylinders are applicable for compressive strengths between 15 to 55 MPa [2000 to 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 single-operator 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 single-operator coefficient of variation of 100 by 200 mm [4 by 8 in.] cylinders are derived from CCRL concrete proficiency sample data for laboratory conditions.

11.1.3 *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 17). A strength test result is the average of two cylinders tested at the same age.

NOTE 17—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.

11.1.4 The multilaboratory data were obtained from six separate organized strength testing round robin programs where 150 by 300 mm [6 by 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 18—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.

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

12. Keywords

12.1 concrete core; concrete cylinder; concrete specimen; concrete strength; compressive strength; core; cylinder; drilled core; strength

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1006. Contact ASTM Customer Service at service@astm.org.

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SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this standard since the last issue (C39/C39M–18) that may impact the use of this standard. (Approved Feb. 1, 2020)

(1) Revised 9.1 to specify the minimum precision of π.

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norma española

UNE-EN 12390-8

Octubre 2009

TÍTULO

Ensayos de hormigón endurecido

Parte 8: Profundidad de penetración de agua bajo presión

Testing hardened concrete. Part 8: Depth of penetration of water under pressure.

Essai pour béton durci. Partie 8: Profondeur de pénétration d'eau sous pression.

CORRESPONDENCIA

Esta norma es la versión oficial, en español, de la Norma Europea EN 12390-8:2009.

OBSERVACIONES

Esta norma anula y sustituye a la Norma UNE-EN 12390-8:2001.

ANTECEDENTES

Esta norma ha sido elaborada por el comité técnico AEN/CTN 83 *Hormigón* cuya Secretaria desempeña ANEFHOP.

Editada e impresa por AENOR
Depósito legal: M 43010:2009

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9 Páginas

Grupo 9

AENOR

NORMA EUROPEA
EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 12390-8

Febrero 2009

ICS 91.100.30

Sustituye a EN 12390-8:2000

Versión en español

Ensayos de hormigón endurecido
Parte 8: Profundidad de penetración de agua bajo presión

Testing hardened concrete. Part 8: Depth of penetration of water under pressure.

Essai pour béton durci. Partie 8: Profondeur de pénétration d'eau sous pression.

Prüfung von Festbeton. Teil 8: Wassereindringtiefe unter Druck.

Esta norma europea ha sido aprobada por CEN el 2008-12-27.

Los miembros de CEN están sometidos al Reglamento Interior de CEN/CENELEC que define las condiciones dentro de las cuales debe adoptarse, sin modificación, la norma europea como norma nacional. Las correspondientes listas actualizadas y las referencias bibliográficas relativas a estas normas nacionales pueden obtenerse en el Centro de Gestión de CEN, o a través de sus miembros.

Esta norma europea existe en tres versiones oficiales (alemán, francés e inglés). Una versión en otra lengua realizada bajo la responsabilidad de un miembro de CEN en su idioma nacional, y notificada al Centro de Gestión, tiene el mismo rango que aquéllas.

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ÍNDICE

PRÓLOGO

Esta Norma EN 12390-8:2009 ha sido elaborada por el Comité Técnico CEN/TC 104 *Hormigón y productos relacionado*, cuya Secretaría desempeña DIN.

Esta norma europea debe recibir el rango de norma nacional mediante la publicación de un texto idéntico a ella o mediante ratificación antes de finales de agosto de 2009, y todas las normas nacionales técnicamente divergentes deben anularse antes de finales de agosto de 2009.

Se llama la atención sobre la posibilidad de que algunos de los elementos de este documento estén sujetos a derechos de patente. CEN y/o CENELEC no es(son) responsable(s) de la identificación de dichos derechos de patente.

Esta norma anula y sustituye a la Norma EN 12390-8:2000.

El campo de aplicación de esta norma se ha restringido a los ensayos sobre probetas curadas en agua.

Esta norma pertenece a una serie de normas relacionadas con los ensayos del hormigón.

La serie de Normas EN 12390 incluye las siguientes partes:

Norma EN 12390 *Ensayos de hormigón endurecido*

Parte 1: Forma, medidas y otras características de las probetas y moldes.

Parte 2: Fabricación y curado de probetas para ensayos de resistencia

Parte 3: Determinación de la resistencia a compresión de probetas

Parte 4: Resistencia a compresión. Características de las máquinas de ensayo.

Parte 5: Resistencia a flexión de probetas.

Parte 6: Resistencia a tracción indirecta de probetas.

Parte 7: Densidad del hormigón endurecido.

Parte 8: Profundidad de penetración de agua bajo presión.

Se han realizado las siguientes modificaciones respecto a la versión 2000-10 de esta norma:

– revisión editorial

De acuerdo con el Reglamento Interior de CEN/CENELEC, están obligados a adoptar esta norma europea los organismos de normalización de los siguientes países: Alemania, Austria, Bélgica, Bulgaria, Chipre, Dinamarca, Eslovaquia, Eslovenia, España, Estonia, Finlandia, Francia, Grecia, Hungría, Irlanda, Islandia, Italia, Letonia, Lituania, Luxemburgo, Malta, Noruega, Países Bajos, Polonia, Portugal, Reino Unido, República Checa, Rumania, Suecia y Suiza.

1 OBJETO Y CAMPO DE APLICACIÓN

Esta norma especifica un método para determinar la profundidad de penetración de agua bajo presión en hormigones endurecidos que han sido curados en agua.

2 NORMAS PARA CONSULTA

Las normas que a continuación se indican son indispensables para la aplicación de esta norma. Para las referencias con fecha, sólo se aplica la edición citada. Para las referencias sin fecha se aplica la última edición de la norma (incluyendo cualquier modificación de ésta).

EN 12390-2 *Ensayos de hormigón endurecido. Parte 2: Fabricación y curado de probetas para ensayos de resistencia.*

3 FUNDAMENTO

Se aplica agua a presión a la superficie del hormigón endurecido. A continuación se divide la probeta por rotura en dos mitades y se mide la profundidad de penetración del frente de agua.

4 APARATOS

4.1 Equipo de ensayo

Debe colocarse la probeta, de unas dimensiones dadas, en cualquier equipo adecuado de modo que la presión del agua pueda actuar sobre la zona ensayada y que permita una lectura continua de la presión aplicada. Un ejemplo de un dispositivo de ensayo se muestra en la figura 1.

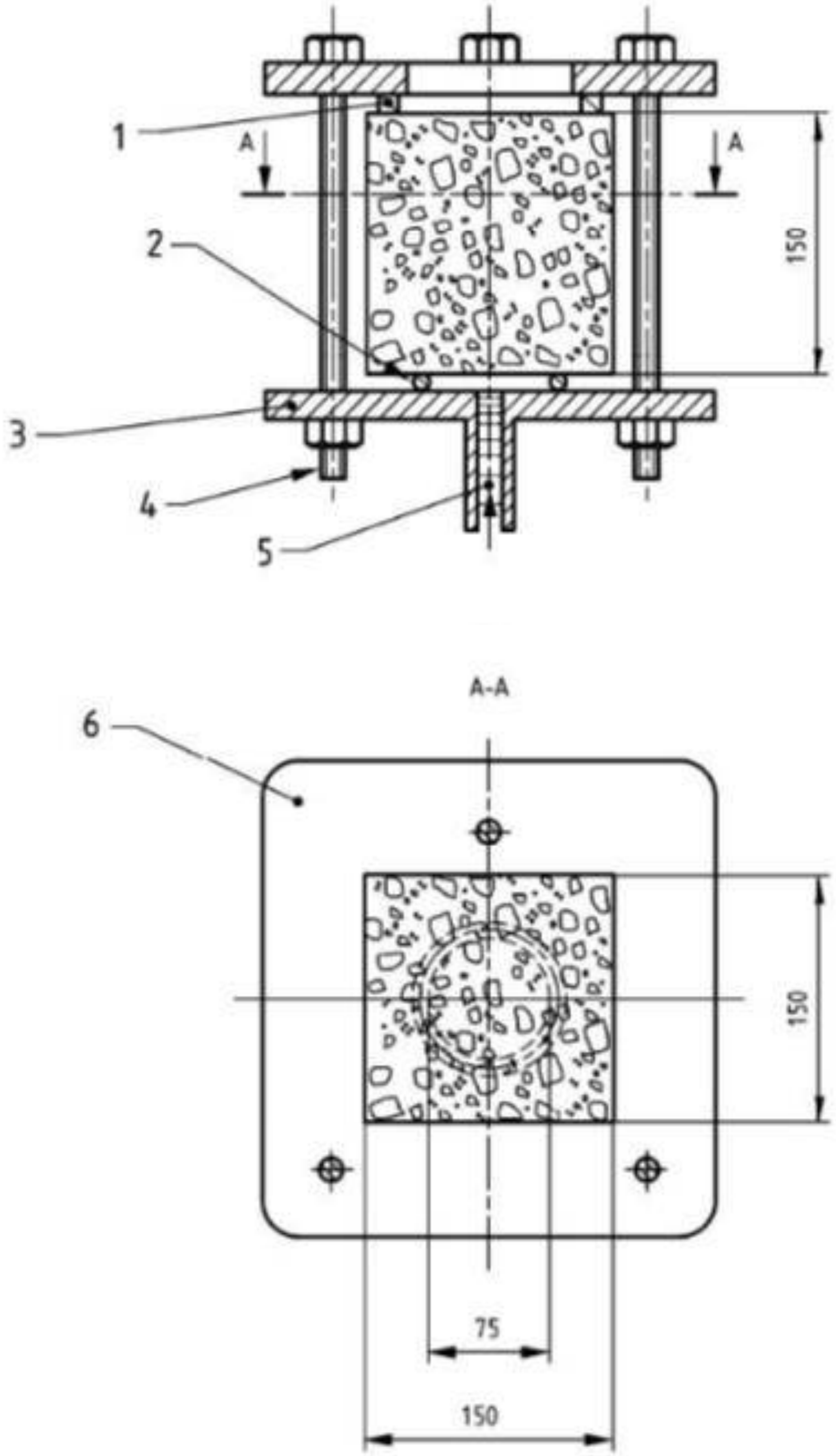
NOTA 1 Es preferible que el aparato permita observar las otras caras de la probeta de ensayo.

NOTA 2 La presión de agua se puede aplicar a la superficie de la probeta de ensayo ya sea por el fondo o por la parte superior.

Se debe realizar un sellado impermeable con caucho u otro material similar.

Las dimensiones de la zona de ensayo deben ser de aproximadamente la mitad de la longitud del lado o del diámetro de la superficie de ensayo.

Medidas en milímetros



Leyenda

1 Soporte
2 Anillo de estanquidad
3 Placa atornillada
4 Soporte atornillado
5 Agua a presión
6 Placa atornillada

Figura 1 – Ejemplo de dispositivo de ensayo

5 PROBETAS DE ENSAYO

Las probetas deben ser cúbicas, cilíndricas o prismáticas, con la dimensión mínima de la superficie de la probeta a ensayar no menor de 150 mm, y ninguna otra dimensión menor de 100 mm.

6 PROCEDIMIENTO

6.1 Preparación de la probeta de ensayo

Inmediatamente después de desmoldar la probeta, se desbasta la superficie de la cara de la probeta que va a estar expuesta a la presión del agua, con un cepillo de púas metálicas y se cura la probeta en agua de acuerdo con los procedimientos indicados en la Norma EN 12390-2.

6.2 Aplicación del agua a presión

El ensayo debe comenzar cuando las probetas tengan al menos una edad de 28 días. No se aplica el agua a presión a la cara fratasada de la probeta. La probeta se coloca en el equipo de ensayo y se aplica al agua una presión de (500 ± 50) kPa durante (72 ± 2) h. Durante el ensayo, se observa periódicamente el estado de las superficies de la probeta de ensayo no expuestas al agua a presión para identificar la posible presencia de agua. Si se observaran filtraciones, se reconsiderara la validez del resultado y se registra el hecho en el informe.

NOTA El uso de agua de red se considera satisfactorio.

6.3 Examen de probeta

Después de aplicar la presión durante el tiempo especificado, se retira la probeta del equipo de ensayo. Se limpia la cara a la que se aplicó la presión de agua para retirar el exceso de agua. Se rompe la probeta en dos mitades, perpendicularmente a la cara en la que se aplica la presión de agua. Cuando se rompa la probeta, y durante el examen, la cara de la probeta expuesta a la presión de agua se situará en el fondo. Tan pronto como la cara partida se ha secado de forma tal que se puede ver claramente la extensión del frente de penetración de agua, se marca en la probeta dicho frente de penetración. Se mide la profundidad máxima de penetración bajo la superficie de ensayo y se redondea al mm más próximo.

7 RESULTADO DEL ENSAYO

El resultado del ensayo es la profundidad máxima de penetración, redondeada al mm más próximo.

8 INFORME DEL ENSAYO

El informe debe incluir:

a) identificación de la probeta de ensayo;

b) fecha y hora de inicio del ensayo;

c) descripción de la probeta (forma y direcciones);

d) dirección de aplicación del agua a presión con relación a la dirección de hormigonado;

e) profundidad de penetración máxima, en mm;

f) cualquier filtración y consideración sobre la validez de los resultados, (si procede);

g) cualquier desviación respecto al método de ensayo normalizado;

h) una declaración de la persona técnicamente responsable de la realización del ensayo de que este fue realizado de acuerdo con esta norma, excepto lo indicado en el punto g).

9 PRECISIÓN

No existen datos disponibles sobre la precisión.

norma española

UNE-EN 12390-8:2009

1ª Modificación

Noviembre 2011

TÍTULO

Ensayos de hormigón endurecido

Parte 8: Profundidad de penetración de agua bajo presión

Testing hardened concrete. Part 8: Depth of penetration of water under pressure.

Essai pour béton durci. Partie 8: Profondeur de pénétration d'eau sous pression.

CORRESPONDENCIA

OBSERVACIONES

Esta 1ª modificación complementa y modifica a la Norma UNE-EN 12390-8:2009

ANTECEDENTES

Esta modificación ha sido elaborada por el comité técnico AEN/CTN 83 *Hormigón* cuya Secretaría desempeña ANEFHOP.

Editada e impresa por AENOR
Depósito legal: M 45383:2011

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4 Páginas

Grupo 2

Este documento forma parte de la biblioteca de SIKA, S.A.

Después del capítulo 9 de la Norma UNE-EN 12390-8:2009 se introduce el siguiente anexo nacional A (informativo)

ANEXO NACIONAL A (Informativo)

DETERMINACIÓN DE LA PROFUNDIDAD MEDIA DE PENETRACIÓN DE AGUA BAJO PRESIÓN

A.0 Introducción

La Instrucción de Hormigón Estructural (EHE-08) establece en sus apartados 37.3.3. *Impermeabilidad del hormigón* y 86.3.3. *Ensayos de penetración de agua en el hormigón*, una especificación para la medida de la profundidad de penetración media de agua bajo presión en el hormigón endurecido.

La Norma UNE-EN 12390-8 establece un método para la determinación de la profundidad de penetración máxima pero no para la determinación de la penetración media.

Este anexo nacional no modifica el método de determinación de la profundidad de penetración máxima de agua bajo presión en hormigón endurecido establecido en la Norma UNE-EN 12390-8, sino que amplía el procedimiento de obtención de resultados de dicha norma para incluir un procedimiento de cálculo para la profundidad media de agua bajo presión.

En este anexo sólo se incluyen aquellos apartados que se han añadido o complementan los correspondientes apartados de la Norma UNE-EN 12390-8.

A.1 Objeto y campo de aplicación

Este anexo, junto con la Norma UNE-EN 12390-8, especifica un método para determinar la profundidad media de penetración de agua bajo presión en hormigones endurecidos.

A.2 Normas para consulta

Los documentos que se citan a continuación son indispensables para la aplicación de esta norma. Únicamente es aplicable la edición de aquellos documentos que aparecen con fecha de publicación. Por el contrario, se aplicará la última edición (incluyendo cualquier modificación que existiera) de aquellos documentos que se encuentran referenciados sin fecha.

UNE-EN 12390-8 *Ensayos de hormigón endurecido. Parte 8: Profundidad de penetración de agua bajo presión.*

A.3 Términos, definiciones y símbolos

A.3.1 Términos y definiciones

A.3.1.1 Frente de penetración: Lugar geométrico de los puntos hasta donde llega el agua al realizar el ensayo.

A.3.1.2 Profundidad de penetración: Distancia entre cada uno de los puntos del frente de penetración y la superficie de la probeta sobre la que se aplica la presión de agua.

A.3.1.3 Profundidad de penetración máxima: Valor máximo de la profundidad de penetración del agua bajo presión determinada de acuerdo con el procedimiento descrito en el capítulo 6 de la Norma UNE-EN 12390-8.

A.3.1.4 Profundidad de penetración media: Profundidad resultante de efectuar el cociente entre el área encerrada por el frente de penetración y el diámetro o la arista de la probeta (véase la figura A.1).

Este documento forma parte de la biblioteca de SIKA, S.A.

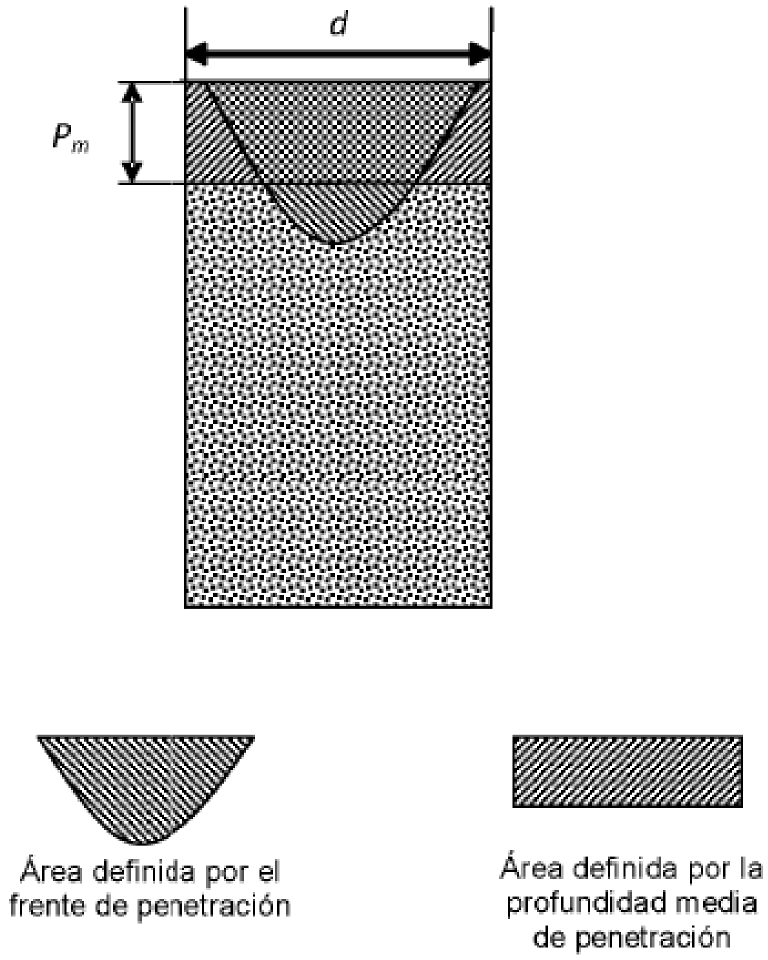


Figura A.1 − Parámetros del frente de penetración

A.3.2 Símbolos

A_{pf} es el área del frente de penetración, en mm^2.

d es el diámetro o arista nominal de la probeta, en mm.

P_m es la profundidad media de penetración, en mm.

A_p es el área del papel empleado en el método recomendado para la determinación del área encerrada por el frente de penetración, en mm^2.

M_p es la masa del papel empleado en el método recomendado, en g.

M_{pf} es la masa del papel cortado empleado en el método recomendado que representa la forma del frente de penetración, en g.

A.4 Materiales (método recomendado)

A.4.1 Hojas de papel vegetal rectangular de dimensiones mayores a las del área definida por el frente de penetración.

A.4.2 Rotulador indeleble que permita marcar de forma clara el frente de penetración.

Este documento forma parte de la biblioteca de SIKA, S.A.

A.5 Aparatos (método recomendado)

A.5.1 Balanza capaz de pesar con una precisión de 0,1 g.

A.5.2 Regla graduada con resolución de 1 mm.

A.6 Procedimiento

A.6.1 Cálculo de la profundidad media de penetración

La profundidad media de penetración se calcula mediante la expresión:

$$P_{\mathrm{m}} = A_{\mathrm{pf}} / d$$

El resultado del cálculo se redondea al mm más próximo.

El área encerrada por el frente de penetración se determina sobre la superficie de fractura que resulta al efectuar el ensayo de determinación de la profundidad máxima de penetración según el procedimiento descrito en el capítulo 6 de la Norma UNE-EN 12390-8.

Para el cálculo del área encerrada por el frente de penetración se pueden aplicar distintos procedimientos, pero por su simplicidad, se recomienda seguir el método indicado en el apartado A.6.2, que es suficientemente preciso.

A.6.2 Determinación del área encerrada por el frente de penetración (método recomendado)

Se pesa una hoja de papel en la balanza y se anota el resultado M_{p}. Se calcula el área del papel A_{p} como producto de las dimensiones de la hoja, medidas en mm.

Se apoya la hoja de papel sobre la cara partida de la probeta y se marca el frente de penetración. Se recorta el perímetro exterior siguiendo el dibujo marcado, para obtener una reproducción del frente de penetración. Se pesa esta reproducción en la balanza y se anota el resultado M_{pf}.

El área definida por el frente de penetración viene dada por la siguiente expresión:

$$A_{\mathrm{pf}} = (A_{\mathrm{p}} \times M_{\mathrm{pf}}) / M_{\mathrm{p}}$$

El resultado de la determinación se redondea al mm^2 más próximo.

A.7 Resultado del ensayo

El resultado del ensayo es la profundidad media de penetración, redondeada al mm más próximo.

A.8 Informe del ensayo

El informe del ensayo debe contener la siguiente información adicional:

i) profundidad de penetración media, en mm.

Este documento forma parte de la biblioteca de SIKA, S.A.

Anexo No. 12: Certificados de calibración

CERTIFICADOS DE CALIBRACIÓN

MULTISERVICIOS Y CONSTRUCTORA

Área de Metrología
Laboratorio de Masa

CERTIFICADO DE CALIBRACIÓN
MT - LM - 300 - 2021

1. Expediente	**210373**
2. Solicitante	**MULTISERVICIOS Y CONSTRUCTORA LH S.A.C**
3. Dirección	Jr. Honduras Mz. B26 Lote 7B Urb. Taparachi 1 Sector, San Ramon - Juliaca - PUNO
4. Equipo de medición	**BALANZA ELECTRÓNICA**
Capacidad Máxima	**6 200 g**
División de escala (d)	**0,1 g**
Div. de verificación (e)	**0,1 g**
Clase de exactitud	**II**
Marca	**OHAUS**
Modelo	**SJX6201/E**
Número de Serie	**B835336209**
Capacidad mínima	**5 g**
Procedencia	**U.S.A.**
Identificación	**NO INDICA**
Ubicación	**LABORATORIO DE SUELOS, CONCRETO Y ASFALTO MULTISERVICIOS Y CONSTRUCTORA LH**
5. Fecha de Calibración	**2021-07-09**

Este certificado de calibración documenta la trazabilidad a los patrones nacionales o internacionales, que realizan las unidades de la medición de acuerdo con el Sistema Internacional de Unidades (SI).

Los resultados son válidos en el momento de la calibración. Al solicitante le corresponde disponer en su momento la ejecución de una recalibración, la cual está en función del uso, conservación y mantenimiento del instrumento de medición o a reglamento vigente.

METROLOGÍA & TÉCNICAS S.A.C. no se responsabiliza de los perjuicios que pueda ocasionar el uso inadecuado de este instrumento, ni de una incorrecta interpretación de los resultados de la calibración aquí declarados.

Este certificado de calibración no podrá ser reproducido parcialmente sin la aprobación por escrito del laboratorio que lo emite.

El certificado de calibración sin firma y sello carece de validez.

Fecha de Emisión	Jefe del Laboratorio de Metrología	Sello
2021-07-10	Firmado digitalmente por Eleazar Cesar Chavez Raraz Fecha: 2021.07.11 23:31:33 -05'00'	METROLOGIA & TECNICAS SAC LABORATORIO PERU

6. Método de Calibración

La calibración se realizó mediante el método de comparación directa, según el PC-001 2da Edición, 2019: "Procedimiento para la calibración de balanzas de funcionamiento no automático clase I y clase II" del INACAL-DM.

7. Lugar de calibración

LABORATORIO DE SUELOS, CONCRETO Y ASFALTO MULTISERVICIOS Y CONSTRUCTORA LH

Jr. Honduras Mz. B26 Lote 7B Urb. Taparachi 1 Sector, San Ramon - Juliaca - PUNO

8. Condiciones Ambientales

	Inicial	Final
Temperatura (°C)	18,0	19,5
Humedad Relativa (%)	59	63

9. Patrones de referencia

Los resultados de la calibración son trazables a la Unidad de Medida de los Patrones Nacionales de Masa de la Dirección de Metrología - INACAL en concordancia con el Sistema Internacional de Unidades de Medidas (SI) y el Sistema Legal de Unidades del Perú (SLUMP).

Trazabilidad	Patrón utilizado	Certificado de calibración
PESAS (Clase de exactitud E1) DM - INACAL LM-075-2020	Pesa (exactitud E2)	LM-C-257-2020
PESAS (Clase de exactitud F1) DM - INACAL IP-214-2020	Pesas (exactitud M1)	SGM-A-2194-2020
PESAS (Clase de exactitud M1) DM - INACAL: SGM-A-1974-2020	Pesas (exactitud M2)	SGM-A-2362-2020
PESA (Clase de exactitud M1) SG NORTEC: SGM-A-1972-2020	Pesa (exactitud M2)	SGM-A-2143-2020
PESA (Clase de exactitud M1) SG NORTEC: SGM-A-1973-2020	Pesa (exactitud M2)	SGM-A-2144-2020

10. Observaciones

- Se colocó una etiqueta autoadhesiva con la indicación de **CALIBRADO.**

CERTIFICADO DE CALIBRACIÓN
MT - LM - 300 - 2021

Área de Metrología
Laboratorio de Masa

11. Resultados de Medición

INSPECCIÓN VISUAL

AJUSTE DE CERO	TIENE	PLATAFORMA	TIENE	ESCALA	NO TIENE
OSCILACIÓN LIBRE	TIENE	SISTEMA DE TRABA	NO TIENE	CURSOR	NO TIENE
		NIVELACIÓN	TIENE		

ENSAYO DE REPETIBILIDAD

	Inicial	Final
Temperatura	18,0 °C	19,5 °C

Medición N°	Carga L1 = 3 000,0 g			Carga L2 6 000,0 g		
	I (g)	ΔL (mg)	E (mg)	I (g)	ΔL (mg)	E (mg)
1	3 000	50	0	6 000	50	0
2	3 000	50	0	6 000	50	0
3	3 001	60	90	6 001	60	90
4	3 000	50	0	6 000	50	0
5	3 000	50	0	6 000	50	0
6	3 000	50	0	6 001	60	90
7	3 001	60	90	6 000	50	0
8	3 000	50	0	6 000	50	0
9	3 000	50	0	6 000	50	0
10	3 000	50	0	6 001	60	90
	Diferencia Máxima		90	Diferencia Máxima		90
	Error Máximo Permisible		± 300	Error Máximo Permisible		± 300

ENSAYO DE EXCENTRICIDAD

2		5
	1	
3		4

Posición de las cargas

	Inicial	Final
Temperatura	16 °C	16,5 °C

Posición de la Carga	Determinación del Error en Cero Eo				Determinación del Error Corregido Ec				
	Carga Mínima*	I (g)	ΔL (mg)	Eo (mg)	Carga (L)	I (g)	ΔL (mg)	E (mg)	Ec (mg)
1	1,0 g	1,0	50	0	2 000,0 g	2 000	50	0	0
2		1,0	50	0		2 000	50	0	0
3		1,0	50	0		2 000	50	0	0
4		1,0	50	0		2 000	50	0	0
5		1,0	50	0		2 000	50	0	0
					Error máximo permisible				± 200

* Valor entre 0 y 10e

Metrologia & Técnicas S.A.C.
Av. San Diego de Alcalá Mz. F1 lote 24 Urb. San Diego , SMP , LIMA
Telf: (511) 540-0642
Cel.: (511) 971 439 272 / 971 439 282
ventas@metrologiatecnicas.com
metrologia@metrologiatecnicas.com
www.metrologiatecnicas.com

ENSAYO DE PESAJE

	Inicial	Final
Temperatura	16,0 °C	16,5 °C

Carga L (g)	CARGA CRECIENTE				CARGA DECRECIENTE				± e.m.p (mg)**
	I (g)	ΔL (mg)	E (mg)	Ec (mg)	I (g)	ΔL (mg)	E (mg)	Ec (mg)	
1,0	1,0	50	0						
5,0	5,0	50	0	0	5,0	50	0	0	100
10,0	10,0	50	0	0	10,0	50	0	0	100
20,0	20,0	50	0	0	20,0	50	0	0	100
50,0	50,0	50	0	0	50,0	50	0	0	100
100,0	100,0	50	0	0	100,0	50	0	0	100
1 000,0	1 000,0	50	0	0	1 000,0	50	0	0	200
2 000,0	2 000,0	50	0	0	2 000,0	50	0	0	200
4 000,0	4 000,0	50	0	0	4 000,0	50	0	0	300
5 000,0	5 000,0	50	0	0	5 000,0	50	0	0	300
6 200,0	6 200,0	50	0	0	6 200,0	50	0	0	300

** error máximo permisible

Leyenda: *L: Carga aplicada a la balanza.* *ΔL: Carga adicional.* *E_o: Error en cero.*
I: Indicación de la balanza. *E: Error encontrado* *E_c: Error corregido.*

LECTURA CORREGIDA : $R_{CORREGIDA} = R + 0{,}00000494 \times R$

INCERTIDUMBRE : $U = 2 \times \sqrt{0{,}00450\ g^2 + 0{,}0000000092 \times R^2}$

12. Incertidumbre

La incertidumbre U reportada en el presente certificado es la incertidumbre expandida de medición que resulta de multiplicar la incertidumbre estándar por el factor de cobertura k=2, el cual proporciona un nivel de confianza de aproximadamente 95%.

La incertidumbre expandida de medición fue calculada a partir de los componentes de incertidumbre de los factores de influencia en la calibración. La incertidumbre indicada no incluye una estimación de variaciones a largo plazo.

CERTIFICADO DE CALIBRACIÓN
MT - LM - 299 - 2021

Área de Metrología
Laboratorio de Masa

1. Expediente	**210373**
2. Solicitante	**MULTISERVICIOS Y CONSTRUCTORA LH S.A.C**
3. Dirección	Jr. Honduras Mz. B26 Lote 7B Urb. Taparachi 1 Sector, San Ramon - Juliaca - PUNO
4. Equipo de medición	**BALANZA ELECTRÓNICA**
Capacidad Máxima	**30 000 g**
División de escala (d)	**1 g**
Div. de verificación (e)	**10 g**
Clase de exactitud	**III**
Marca	**OHAUS**
Modelo	**R31P30**
Número de Serie	**8339530197**
Capacidad mínima	**20 g**
Procedencia	**U.S.A.**
Identificación	**NO INDICA**
Ubicación	**LABORATORIO DE SUELOS, CONCRETO Y ASFALTO MULTISERVICIOS Y CONSTRUCTORA LH**
5. Fecha de Calibración	**2021-07-09**

Este certificado de calibración documenta la trazabilidad a los patrones nacionales o internacionales, que realizan las unidades de la medición de acuerdo con el Sistema Internacional de Unidades (SI).

Los resultados son válidos en el momento de la calibración. Al solicitante le corresponde disponer en su momento la ejecución de una recalibración, la cual está en función del uso, conservación y mantenimiento del instrumento de medición o a reglamento vigente.

METROLOGÍA & TÉCNICAS S.A.C. no se responsabiliza de los perjuicios que pueda ocasionar el uso inadecuado de este instrumento, ni de una incorrecta interpretación de los resultados de la calibración aquí declarados.

Este certificado de calibración no podrá ser reproducido parcialmente sin la aprobación por escrito del laboratorio que lo emite.

El certificado de calibración sin firma y sello carece de validez.

Fecha de Emisión	Jefe del Laboratorio de Metrología	Sello
2021-07-10	Firmado digitalmente por Eleazar Cesar Chavez Raraz Fecha: 2021.07.10 11:37:57 -05'00'	METROLOGIA & TECNICAS SAC LABORATORIO PERU

6. Método de Calibración

La calibración se realizó mediante el método de comparación directa, según el PC-001 1ra Edición, 2019: "Procedimiento para la calibración de balanzas de funcionamiento no automático clase III y clase IIII" del INACAL-DM.

7. Lugar de calibración

LABORATORIO DE SUELOS, CONCRETO Y ASFALTO MULTISERVICIOS Y CONSTRUCTORA LH
Jr. Honduras Mz. B26 Lote 7B Urb. Taparachi 1 Sector, San Ramon - Juliaca - PUNO

8. Condiciones Ambientales

	Inicial	Final
Temperatura (°C)	16,0	16,5
Humedad Relativa (%)	58	60

9. Patrones de referencia

Los resultados de la calibración son trazables a la Unidad de Medida de los Patrones Nacionales de Masa de la Dirección de Metrología - INACAL en concordancia con el Sistema Internacional de Unidades de Medidas (SI) y el Sistema Legal de Unidades del Perú (SLUMP).

Trazabilidad	Patrón utilizado	Certificado de calibración
PESAS (Clase de exactitud E1) DM - INACAL LM-075-2020	Pesa (exactitud E2)	LM-C-257-2020
PESAS (Clase de exactitud F1) DM - INACAL IP-214-2020	Pesas (exactitud M1)	SGM-A-2194-2020
PESAS (Clase de exactitud M1) DM - INACAL: SGM-A-1974-2020	Pesas (exactitud M2)	SGM-A-2362-2020
PESA (Clase de exactitud M1) SG NORTEC: SGM-A-1972-2020	Pesa (exactitud M2)	SGM-A-2143-2020
PESA (Clase de exactitud M1) SG NORTEC: SGM-A-1973-2020	Pesa (exactitud M2)	SGM-A-2144-2020

10. Observaciones

- Se colocó una etiqueta autoadhesiva con la indicación de **CALIBRADO.**

CERTIFICADO DE CALIBRACIÓN
MT - LM - 299 - 2021

Área de Metrología
Laboratorio de Masa

11. Resultados de Medición

INSPECCIÓN VISUAL

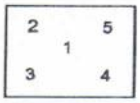
AJUSTE DE CERO	TIENE	PLATAFORMA	TIENE	ESCALA	NO TIENE
OSCILACIÓN LIBRE	TIENE	SISTEMA DE TRABA	NO TIENE	CURSOR	NO TIENE
		NIVELACIÓN	TIENE		

ENSAYO DE REPETIBILIDAD

	Inicial	Final
Temperatura	16 °C	16,3 °C

Medición	Carga L1 = 15 000,0 g			Carga L2 = 30 000,0 g		
Nº	I (g)	ΔL (g)	E (g)	I (g)	ΔL (g)	E (g)
1	15 000	0,6	-0,1	30 000	0,8	-0,3
2	15 000	0,4	0,1	30 000	0,6	-0,1
3	15 000	0,2	0,3	30 000	0,7	-0,2
4	15 000	0,3	0,2	30 000	0,7	-0,2
5	15 000	0,3	0,2	30 000	0,6	-0,1
6	15 000	0,4	0,1	30 000	0,6	-0,1
7	15 000	0,4	0,1	30 000	0,7	-0,2
8	15 000	0,5	0,0	30 000	0,8	-0,3
9	15 000	0,5	0,0	30 000	0,6	-0,1
10	15 000	0,4	0,1	30 000	0,7	-0,2
	Diferencia Máxima		0,4	Diferencia Máxima		0,2
	Error Máximo Permisible		± 20,0	Error Máximo Permisible		± 30,0

ENSAYO DE EXCENTRICIDAD



Posición de las cargas

	Inicial	Final
Temperatura	16 °C	16,5 °C

Posición de la Carga	Determinación del Error en Cero Eo				Determinación del Error Corregido Ec				
	Carga Mínima*	I (g)	ΔL (g)	Eo (g)	Carga (L)	I (g)	ΔL (g)	E (g)	Ec (g)
1	10,0 g	10	0,6	-0,1	10 000,0 g	10 000	0,6	-0,1	0,0
2		10	0,6	-0,1		10 001	0,8	0,7	0,8
3		10	0,6	-0,1		9 999	0,3	-0,8	-0,7
4		10	0,6	-0,1		10 000	0,5	0,0	0,1
5		10	0,6	-0,1		10 000	0,4	0,1	0,2
					Error máximo permisible				± 20,0

* Valor entre 0 y 10e

CERTIFICADO DE CALIBRACIÓN
MT - LM - 299 - 2021

Área de Metrología
Laboratorio de Masa

ENSAYO DE PESAJE

	Inicial	Final
Temperatura	16,3 °C	16,5 °C

Carga L (g)	CARGA CRECIENTE				CARGA DECRECIENTE				± e.m.p (g)**
	I (g)	ΔL (g)	E (g)	Ec (g)	I (g)	ΔL (g)	E (g)	Ec (g)	
10,0	10	0,8	-0,3						
20,0	20	0,8	-0,3	0,0	20	0,5	0,0	0,3	10,0
100,0	100	0,7	-0,2	0,1	100	0,5	0,0	0,3	10,0
500,0	500	0,7	-0,2	0,1	500	0,5	0,0	0,3	10,0
1 000,0	1 000	0,6	-0,1	0,2	1 000	0,4	0,1	0,4	10,0
5 000,1	5 000	0,6	-0,2	0,1	5 000	0,4	0,0	0,3	10,0
10 000,2	10 000	0,5	-0,2	0,1	10 001	0,8	0,5	0,8	20,0
15 000,3	15 000	0,4	-0,2	0,1	15 001	0,8	0,4	0,7	20,0
20 000,4	20 000	0,4	-0,3	0,0	20 001	0,9	0,2	0,5	20,0
25 000,5	25 000	0,4	-0,4	-0,1	25 001	0,8	0,2	0,5	30,0
30 000,6	30 000	0,3	-0,4	-0,1	30 000	0,3	-0,4	-0,1	30,0

** error máximo permisible

Leyenda: *L: Carga aplicada a la balanza.* *ΔL: Carga adicional.* *E_O: Error en cero.*
I: Indicación de la balanza. *E: Error encontrado* *E_C: Error corregido.*

LECTURA CORREGIDA : $R_{CORREGIDA} = R - 1,48 \times 10^{-6} \times R$

INCERTIDUMBRE : $U = 2 \times \sqrt{2,21 \times 10^{-1}\ g^2 + 8,49 \times 10^{-10} \times R^2}$

12. Incertidumbre

La incertidumbre U reportada en el presente certificado es la incertidumbre expandida de medición que resulta de multiplicar la incertidumbre estándar por el factor de cobertura k=2, el cual proporciona un nivel de confianza de aproximadamente 95%.

La incertidumbre expandida de medición fue calculada a partir de los componentes de incertidumbre de los factores de influencia en la calibración. La incertidumbre indicada no incluye una estimación de variaciones a largo plazo.

CERTIFICADO DE CALIBRACIÓN
MT - LT - 115 - 2021

Área de Metrología
Laboratorio de Temperatura

1. Expediente **210373**

2. Solicitante **MULTISERVICIOS Y CONSTRUCTORA LH S.A.C**

3. Dirección Jr. Honduras Mz. B26 Lote 7B Urb. Taparachi 1 Sector, San Ramon - Juliaca - PUNO

4. Equipo **HORNO**

Alcance Máximo De 0 °C a 300 °C

Marca A&A INSTRUMENTS

Modelo STHX-1A

Número de Serie 190548

Procedencia CHINA

Identificación NO INDICA

Ubicación **LABORATORIO DE SUELOS, CONCRETO Y ASFALTO MULTISERVICIOS Y CONSTRUCTORA LH**

Descripción	Controlador / Selector	Instrumento de medición
Alcance	0 °C a 300 °C	0 °C a 300 °C
División de escala / Resolución	0,1 °C	0,1 °C
Tipo	DIGITAL	TERMÓMETRO DIGITAL

Este certificado de calibración documenta la trazabilidad a los patrones nacionales o internacionales, que realizan las unidades de la medición de acuerdo con el Sistema Internacional de Unidades (SI).

Los resultados son validos en el momento de la calibración. Al solicitante le corresponde disponer en su momento la ejecución de una recalibración, la cual está en función del uso, conservación y mantenimiento del instrumento de medición o a reglamento vigente.

METROLOGÍA & TÉCNICAS S.A.C. no se responsabiliza de los perjuicios que pueda ocasionar el uso inadecuado de este instrumento, ni de una incorrecta interpretación de los resultados de la calibración aqui declarados.

Este certificado de calibración no podrá ser reproducido parcialmente sin la aprobación por escrito del laboratorio que lo emite.

El certificado de calibración sin firma y sello carece de validez.

5. Fecha de Calibración **2021-07-09**

Fecha de Emisión	**Jefe del Laboratorio de Metrología**	**Sello**
2021-07-10	Firmado digitalmente por Eleazar Cesar Chavez Raraz Fecha: 2021.07.10 11:43:53 -05'00'	METROLOGIA & TECNICAS S.A.C. LABORATORIO PERU

6. Método de Calibración

La calibración se efectuó por comparación directa de acuerdo al PC-018 "Procedimiento para la Calibración de Medios Isotérmicos con Aire como Medio Termostatico", 2da edición, publicado por el SNM-INDECOPI, 2009.

7. Lugar de calibración

LABORATORIO DE SUELOS, CONCRETO Y ASFALTO MULTISERVICIOS Y CONSTRUCTORA LH
Calle Santa Luisa 106, Ate - Lima - LIMA

8. Condiciones Ambientales

	Inicial	Final
Temperatura	16,5 °C	17,1 °C
Humedad Relativa	55 %	56 %

El tiempo de calentamiento y estabilización del equipo fue de 120 minutos.
El controlador se seteo en 110 ° C

9. Patrones de referencia

Trazabilidad	Patrón utilizado	Certificado y/o Informe de calibración
Dirección de Metrología INACAL LT - 091 - 2019	TERMÓMETRO DE INDICACIÓN DIGITAL CON 12 CANALES	LT - 0083 - 2021
Fluke Corporation C0721069		

10. Observaciones

- Se colocó una etiqueta autoadhesiva con la indicación de **CALIBRADO**.
- La periodicidad de la calibración depende del uso, mantenimiento y conservación del instrumento de medición.

CERTIFICADO DE CALIBRACIÓN
MT - LT - 115 - 2021

Área de Metrología
Laboratorio de Temperatura

11. Resultados de Medición

PARA LA TEMPERATURA DE 110 °C

Tiempo (min)	Termómetro del equipo (°C)	TEMPERATURAS EN LAS POSICIONES DE MEDICIÓN (°C) — NIVEL SUPERIOR 1	2	3	4	5	NIVEL INFERIOR 6	7	8	9	10	T_{prom} (°C)	$T_{máx}-T_{m}$
00	110,0	106,2	109,6	108,8	107,2	108,6	110,7	113,9	111,3	108,5	108,6	109,3	7,6
02	110,0	106,2	109,7	109,0	107,4	108,8	110,6	114,0	111,4	108,4	108,7	109,4	7,7
04	110,0	106,0	109,9	109,0	107,5	108,9	110,5	114,0	111,5	108,3	108,7	109,4	7,9
06	110,0	106,1	109,7	108,9	107,4	108,8	110,5	114,1	111,4	108,2	108,7	109,4	7,9
08	110,0	106,2	109,8	109,1	107,6	108,9	110,6	114,4	111,4	108,4	108,6	109,5	8,1
10	110,0	106,1	109,9	108,9	107,5	108,8	110,7	114,4	111,4	108,3	108,6	109,5	8,2
12	110,0	106,0	109,7	108,9	107,6	108,7	110,8	114,5	111,4	108,3	108,5	109,4	8,4
14	110,0	106,1	109,8	109,0	107,6	108,9	110,8	114,3	111,5	108,3	108,5	109,5	8,1
16	110,0	106,2	109,8	108,9	107,5	108,8	110,6	114,3	111,4	108,1	108,4	109,4	8,0
18	110,0	106,1	109,8	109,0	107,5	108,9	110,8	114,4	111,5	108,2	108,5	109,5	8,2
20	110,0	106,1	109,7	108,9	107,5	108,7	110,6	114,2	111,4	108,1	108,6	109,4	8,0
22	110,0	106,1	109,6	108,9	107,5	108,8	110,5	114,2	111,5	108,2	108,5	109,4	8,0
24	110,0	106,3	109,7	109,0	107,6	108,8	110,7	114,3	111,3	108,3	108,6	109,5	7,9
26	109,9	106,2	109,7	108,9	107,5	108,7	110,6	114,2	111,4	108,3	108,5	109,4	7,9
28	110,0	106,1	109,6	109,0	107,4	108,7	110,7	114,1	111,3	108,2	108,4	109,3	7,9
30	110,0	106,2	109,6	109,0	107,4	108,7	110,7	114,1	111,3	108,2	108,5	109,4	7,8
32	110,0	106,0	109,8	109,0	107,5	108,7	110,7	114,1	111,3	108,3	108,6	109,4	8,0
34	110,0	105,9	110,0	108,9	107,4	108,8	110,6	114,2	111,3	108,1	108,5	109,4	8,2
36	110,0	106,1	109,8	109,0	107,6	108,7	110,5	114,3	111,4	108,1	108,6	109,4	8,1
38	110,0	106,0	109,9	109,0	107,5	108,8	110,6	114,2	111,3	108,1	108,6	109,4	8,1
40	110,0	106,1	109,8	108,9	107,5	108,8	110,6	114,3	111,4	108,2	108,6	109,4	8,1
42	110,0	106,1	109,8	109,0	107,4	108,7	110,5	114,2	111,3	108,1	108,6	109,4	8,0
44	110,0	106,2	109,7	108,9	107,5	108,7	110,6	114,1	111,3	108,2	108,5	109,4	7,8
46	110,0	106,1	109,8	109,0	107,6	108,7	110,5	114,2	111,4	108,1	108,4	109,4	8,0
48	110,0	106,1	109,7	108,9	107,6	108,7	110,6	114,3	111,2	108,1	108,3	109,3	8,1
50	110,0	106,1	109,7	108,8	107,5	108,7	110,5	114,2	111,3	108,1	108,2	109,3	8,0
52	110,0	106,2	109,8	109,0	107,6	108,8	110,6	114,3	111,4	108,1	108,3	109,4	8,0
54	110,0	106,1	109,6	108,9	107,5	108,6	110,7	114,2	111,3	108,2	108,4	109,3	8,0
56	110,0	106,1	109,6	108,8	107,5	108,6	110,6	114,2	111,4	108,1	108,5	109,3	8,0
58	110,0	106,1	109,6	108,8	107,5	108,5	110,6	114,2	111,4	108,1	108,4	109,3	8,0
60	110,1	106,1	109,6	108,8	107,5	108,6	110,5	114,1	111,3	108,1	108,5	109,3	7,9
T.PROM	110,0	106,1	109,7	108,9	107,5	108,8	110,6	114,2	111,3	108,2	108,5	109,4	
T.MAX	110,1	106,3	110,0	109,1	107,6	108,9	110,8	114,5	111,5	108,5	108,7		
T.MIN	109,9	105,9	109,6	108,8	107,2	108,5	110,5	113,9	111,2	108,1	108,2		
DTT	0,2	0,4	0,4	0,3	0,4	0,4	0,3	0,6	0,3	0,4	0,5		

CERTIFICADO DE CALIBRACIÓN
MT - LT - 115 - 2021

Área de Metrología
Laboratorio de Temperatura

PARÁMETRO	VALOR (°C)	INCERTIDUMBRE EXPANDIDA (°C)
Máxima Temperatura Medida	114,5	0,2
Mínima Temperatura Medida	105,9	0,2
Desviación de Temperatura en el Tiempo	0,6	0,1
Desviación de Temperatura en el Espacio	8,0	0,1
Estabilidad Medida (±)	0,3	0,04
Uniformidad Medida	8,4	0,1

T.PROM : Promedio de la temperatura en una posición de medición durante el tiempo de calibración.
T prom : Promedio de las temperaturas en la diez posiciones de medición para un instante dado.
T.MAX : Temperatura máxima.
T.MIN : Temperatura mínima.
DTT : Desviación de Temperatura en el Tiempo.

Para cada posición de medición su **"desviación de temperatura en el tiempo"** DTT está dada por la diferencia entre la máxima y la mínima temperatura en dicha posición.
Entre dos posiciones de medición su **"desviación de temperatura en el espacio"** está dada por la diferencia entre los promedios de temperaturas registradas en ambas posiciones.

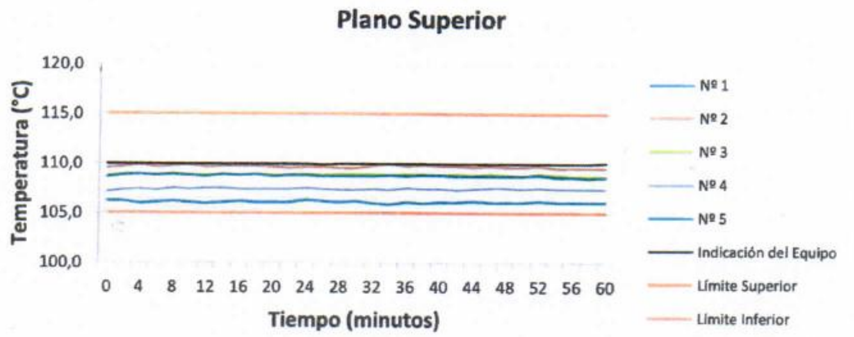
Incertidumbre expandida de las indicaciones del termómetro propio del Medio Isotermo : 0,03 °C

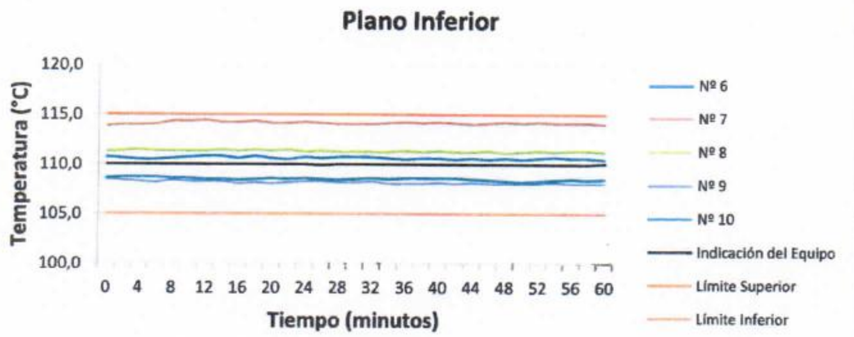
La incertidumbre expandida de medición fue calculada a partir de los componentes de incertidumbre de los factores de influencia en la calibración. La incertidumbre indicada no incluye una estimación de variaciones a largo plazo.

La uniformidad es la máxima diferencia medida de temperatura entre las diferentes posiciones espaciales para un mismo instante de tiempo.

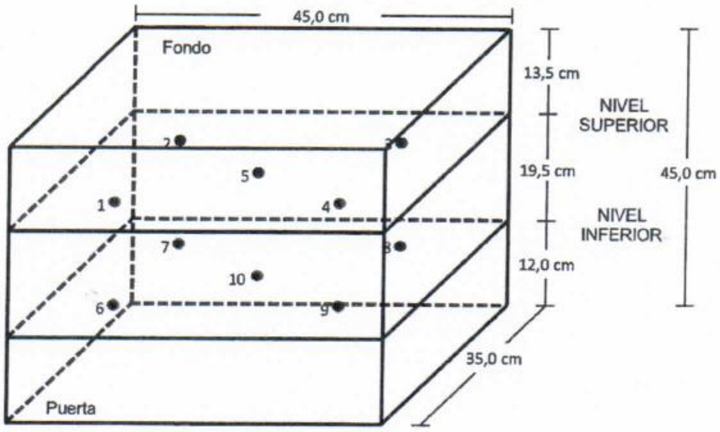
La estabilidad es considerada igual a ± 1/2 DTT.

DISTRIBUCIÓN DE TEMPERATURAS EN EL EQUIPO
TEMPERATURA DE TRABAJO: 110 °C ± 5 °C





DISTRIBUCIÓN DE LOS TERMOPARES



Los sensores 5 y 10 están ubicados en el centro de sus respectivos niveles.

Los sensores del 1 al 4 y del 6 al 9 se colocaron a 8 cm de las paredes laterales y a 6 cm del fondo y frente del equipo a calibrar.

12. Incertidumbre

La incertidumbre reportada en el presente certificado es la incertidumbre expandida de medición que resulta de multiplicar la incertidumbre estandar por el factor de cobertura k=2, el cual proporciona un nivel de confianza de aproximadamente 95%.

Fin del documento

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM E11 – 15

ISSUE DATE: 2/21/2019

3"BS8F879694

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

This is to certify that the openings in the wire cloth used in the manufacture of this test sieve have been checked through advanced optical technology to assure conformity to ASTM Specification E 11-15

The dimensions of the test sieve frame have also been checked with precision gauges to assure conformity to these specifications.

MANUFACTURED IN THE U.S.A. BY ADVANTECH MANUFACTURING

ISSUE DATE: 6/21/2018

100BS8F850040

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM E11 – 15

ISSUE DATE: 3/26/2019

2.5"BS8F873112

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM E11 – 15

ISSUE DATE: 2/21/2019

2"BS8F875288

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

This is to certify that the openings in the wire cloth used in the manufacture of this test sieve have been checked through advanced optical technology to assure conformity to ASTM Specification E 11-15

The dimensions of the test sieve frame have also been checked with precision gauges to assure conformity to these specifications.

MANUFACTURED IN THE U.S.A. BY ADVANTECH MANUFACTURING

ISSUE DATE: 6/28/2018

1.5"BS8F849616

CERTIFICATE OF COMPLIANCE
to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM E11 – 15

ISSUE DATE: 2/20/2019

1.0"BS8F873135

CERTIFICATE OF COMPLIANCE
to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM E11 – 15

ISSUE DATE: 11/26/2018

3/4"BS8F862818

CERTIFICATE OF COMPLIANCE
to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM E11 – 15

ISSUE DATE: 11/26/2018

1/2"BS8F871084

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM-E11 – 15

ISSUE DATE: 2/20/2019

3/8"BS8F879382

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM E11 – 15

ISSUE DATE: 3/21/2019

8BS8F881155

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

This is to certify that the openings in the wire cloth used in the manufacture of this test sieve have been checked through advanced optical technology to assure conformity to ASTM Specification E 11-15

The dimensions of the test sieve frame have also been checked with precision gauges to assure conformity to these specifications.

MANUFACTURED IN THE U.S.A. BY ADVANTECH MANUFACTURING

ISSUE DATE: 6/21/2018

4BS8F849972

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

This is to certify that the openings in the wire cloth used in the manufacture of this test sieve have been checked through advanced optical technology to assure conformity to ASTM Specification E 11-15

The dimensions of the test sieve frame have also been checked with precision gauges to assure conformity to these specifications.

MANUFACTURED IN THE U.S.A. BY ADVANTECH MANUFACTURING

ISSUE DATE: 6/25/2018

10BS8F850657

CERTIFICATE OF COMPLIANCE
to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM E11 – 15

MADE IN THE USA

ISSUE DATE: 12/12/2018

16BS8F869639

CERTIFICATE OF COMPLIANCE
to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM E11 – 15

MADE IN THE USA

ISSUE DATE: 2/21/2019

20BS8F875473

CERTIFICATE OF COMPLIANCE
to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM E11 – 15

MADE IN THE USA

ISSUE DATE: 1/22/2019

30BS8F877261

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

This is to certify that the openings in the wire cloth used in the manufacture of this test sieve have been checked through advanced optical technology to assure conformity to ASTM Specification E 11- 15

The dimensions of the test sieve frame have also been checked with precision gauges to assure conformity to these specifications.

MANUFACTURED IN THE U.S.A. BY ADVANTECH MANUFACTURING

ISSUE DATE: 10/21/2016

40BS8F775257

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

This is to certify that the openings in the wire cloth used in the manufacture of this test sieve have been checked through advanced optical technology to assure conformity to ASTM Specification E 11- 15

The dimensions of the test sieve frame have also been checked with precision gauges to assure conformity to these specifications.

MANUFACTURED IN THE U.S.A. BY ADVANTECH MANUFACTURING

ISSUE DATE: 6/21/2018

50BS8F850036

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM E11 – 15

ISSUE DATE: 9/5/2018

80BS8F859403

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

This is to certify that the openings in the wire cloth used in the manufacture of this test sieve have been checked through advanced optical technology to assure conformity to ASTM Specification E 11- 15

The dimensions of the test sieve frame have also been checked with precision gauges to assure conformity to these specifications.

MANUFACTURED IN THE U.S.A. BY ADVANTECH MANUFACTURING

ISSUE DATE: 7/18/2018

60BS8F853229

CERTIFICATE OF COMPLIANCE

to specifications of

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

ISO – International Standards Organization

We certify that this test sieve has been manufactured with sieve cloth and component parts that have been inspected and found to be in compliance with the requirements of Specification ASTM E11 – 15

ISSUE DATE: 9/19/2018

200BS8F861281

FICHA TECNICA

CANASTA PARA DENSIDAD

MANUFACTURADO POR

TECNICAS CP S.A.C.

EQUIPOS DE LABORATORIO

DESCRIPCIÓN DEL EQUIPO:

Accesorio para la determinación de gravedad específica de concreto fresco y endurecido y agregados.

ESTANDARES: EN 1097-6, 12390-7

DIMENCIONES:
Todas las dimensiones están en milímetros:

MODELO	*TCP-008*
Diámetro	*200 mm*
Diámetro Malla	*3.5 mm*
Profundidad	*200 mm*
Serie	*AA01*

Este certificado se emite como una declaración del hecho de que en esta fecha el instrumento tiene una precisión como se indica. No debe interpretarse ni considerarse como una garantía o garantía de ningún tipo (en favor del cliente, de los clientes o del público en general) que el (los) instrumento (s) seguirá manteniendo el mismo porcentaje (%), De exactitud o eficiencia, tal como se determina en la fecha, cuando la calibración y los ajustes, si es necesario, fueron realizados e informados por : TECNICAS CP SAC, ya que la calibración no tiene absolutamente ningún control sobre la operación futura, daños o pérdidas sufridos por todas las partes Del deterioro, de la obsolescencia, del malfuncionamiento, o de la sub-ejecución estándar de dicho Instrumento (s): que se considerará y que seguirá siendo la única responsabilidad del custodio, propietario y / o fabricante del equipo.

ANGEL ROBLES ORELLANA
INGENIERO AGROINDUSTRIAL

Ing. Angel Robles Orellana

Av. Santa Ana Mz. H Lt.2, San Diego, Urb. San Diego.
Telf.: 540-2790 Anexo 131
RPC: 964312906
E-mail: mantenimiento@tecnicascp.com.pe
WWW.tecnicascp.com.pe

Product Certification
This is to Certify

that the material herein identified has been inspected and calibrated (when applicable) in accordance with standard procedures set forth and is found to be within the prescribed tolerances.

PRODUCT MANUFACTURE: FORNEY, LLC

PRODUCT ITEM NUMBER: LA-3035

MANUFACTURING SPECIFICATIONS: ASTM D698, D1557, AASHTO T 99, T 180.

PRODUCT DESCRIPTION: COMPACTION MOLDS, 6 IN

MODELO: LA-3035

SERIE: 531

FORNEY REPRESENTATIVE

This Certificate is issued as a statement of the fact that on this date the above instruments(s) had an accuracy as indicated. It should not be construed or regarded as a Guarantee or Warranty of any kind (in favor of the client, the client's customers, or the public at large) that the instrument(s) will continue to retain the same percentage (%) of accuracy or efficiency as determined on the date, when the calibration, and adjustments if required was performed and reported by "FORNEY INCORPORATED", since the calibrator has absolutely no control over the future operation, damage, maintenance repairs and overall condition of the instrument(s) and hereby expressly disclaims any and all liability for damage or loss sustained by all parties arising or resulting from deterioration, obsolescence, malfunction, or sub-standard performance of said instrument(s): which shall be deemed to be and which shall remain the sole responsibility of the machines regular custodian, owner and/or manufacturer.

FORNEY

WORLD EXPERTS IN MATERIAL TESTING
1565 Broadway Ave., Hermitage, PA 16148
Phone 724-346-7400 Fax: 724-346-7408
email – sales@forneyonline.com

CERTIFICADO DE CALIBRACIÓN
MT - LT - 116 - 2021

Área de Metrología

Laboratorio de Temperatura

1. Expediente	**210373**
2. Solicitante	**MULTISERVICIOS Y CONSTRUCTORA LH S.A.C**
3. Dirección	Jr. Honduras Mz. B26 Lote 7B Urb. Taparachi 1 Sector, San Ramon - Juliaca - PUNO
4. Instrumento de medición	**TERMÓMETRO DE INDICACIÓN DIGITAL**
Alcance de Indicación	**-50 °C a 300 °C**
Div. de escala / Resolución	**0,1 °C**
Marca	**CONTROL COMPANY**
Modelo	**4353**
Número de Serie	**181528649**
Procedencia	**U.S.A.**
Elemento Sensor	**TERMISTOR**
Identificación	**NO INDICA**
5. Fecha de Calibración	**2021-07-09**

Este certificado de calibración documenta la trazabilidad a los patrones nacionales o internacionales, que realizan las unidades de la medición de acuerdo con el Sistema Internacional de Unidades (SI).

Los resultados son validos en el momento de la calibración. Al solicitante le corresponde disponer en su momento la ejecución de una recalibración, la cual está en función del uso, conservación y mantenimiento del instrumento de medición o a reglamento vigente.

METROLOGÍA & TÉCNICAS S.A.C. no se responsabiliza de los perjuicios que pueda ocasionar el uso inadecuado de este instrumento, ni de una incorrecta interpretación de los resultados de la calibración aquí declarados.

Este certificado de calibración no podrá ser reproducido parcialmente sin la aprobación por escrito del laboratorio que lo emite.

El certificado de calibración sin firma y sello carece de validez.

Fecha de Emisión	Jefe del Laboratorio de Metrología	Sello
2021-07-10	Firmado digitalmente por Eleazar Cesar Chavez Raraz Fecha: 2021.07.10 11:43:21 -05'00'	METROLOGIA & TECNICAS S.A.C. LABORATORIO PERU

6. Método de Calibración

La calibración se realizó por el método de comparación directa utilizando patrones trazables al SNM/INDECOPI tomado como referencia el PC-017 "*Procedimiento para la Calibración de Termómetros Digitales*" Segunda edición - diciembre 2012 de INDECOPI/SNM.

7. Lugar de calibración

Laboratorio de Temperatura de METROLOGÍA & TÉCNICAS S.A.C. - METROTEC
Av. San Diego de Acalá Mz. F1 lote 24 Urb. San Diego, San Martín de Porres - Lima

8. Condiciones Ambientales

	Mínimo	Máximo
Temperatura	17,5 °C	17,7 °C
Humedad Relativa	47,2 %	48,3 %

9. Patrones de referencia

Trazabilidad	Patrón utilizado	Certificado de calibración
Patrones de referencia de la Dirección de Metrologia INACAL	Termómetro Digital con incertidumbres del orden desde 0,025 °C hasta 0,04 °C	DM INACAL LT-256-2020
		DM INACAL LT-255-2020

10. Observaciones

- Se colocó una etiqueta autoadhesiva con la indicación **CALIBRADO**.

11. Resultados de Medición

INDICACIÓN DEL TERMOMETRO (°C)	TEMPERATURA CONVENCIONALMENTE VERDADERA (°C)	CORRECCIÓN (°C)	INCERTIDUMBRE (K=2) (°C)
9,9	9,78	-0,12	0,14
20,0	19,75	-0,25	0,14
40,5	40,19	-0,31	0,14

TCV (Temperatura Convencionalmente Verdadera) = Indicación del termómetro + Corrección

Nota 1.- La profundidad de inmersión del sensor fue 140 mm de aproximadamente.
Nota 2.- Tiempo de estabilización no menor a 10 minutos.

12. Incertidumbre

La incertidumbre expandida de medición se ha obtenido multiplicando la incertidumbre estándar de la medición por el factor de cobertura k=2, el cual corresponde a una probabilidad de cobertura de aproximadamente 95%.
La incertidumbre expandida de medición fue calculada a partir de los componentes de incertidumbre de los factores de influencia en la calibración. La incertidumbre indicada no incluye una estimación de variaciones a largo plazo.

Fin de documento

Área de Metrología
Laboratorio de Presión

CERTIFICADO DE CALIBRACIÓN
CA- LP - 014 - 2022

1. Expediente	**0325-2022**
2. Solicitante	**MULTISERVICIOS Y CONSTRUCTORA LH SOCIEDAD ANÓNIMA CERRADA**
3. Dirección	JR. HONDURAS LT. 7B MZ. B26 URB. TAPARACHI 1 S ECTOR - JULIACA - PUNO - SAN ROMAN
4. Instrumento de Medición	**OLLA WASHINGTON** (PRESS-AIR METER)
Volumen	7.1 l
Marca	FORNEY
Modelo	LA-0316
Número de Serie	114
Procedencia	U.S.A.
Identificación	NO INDICA
Tipo de Indicación	Analógico
Alcance de Indicación	100% a 0% (Contenido de aire) 0 a 15 psi
5. Fecha de Calibración	2022-02-05

Este certificado de calibración documenta la trazabilidad a los patrones nacionales o internacionales, que realizan las unidades de la medición de acuerdo con el Sistema Internacional de Unidades (SI).

Los resultados son validos en el momento de la calibración. Al solicitante le corresponde disponer en su momento la ejecución de una recalibración, la cual está en función del uso, conservación y mantenimiento del instrumento de medición o a reglamento vigente.

CALIBRATEC S.A.C. no se responsabiliza de los perjuicios que pueda ocasionar el uso inadecuado de este instrumento, ni de una incorrecta interpretación de los resultados de la calibración aqui declarados.

Este certificado de calibración no podrá ser reproducido parcialmente sin la aprobación por escrito del laboratorio que lo emite.

El certificado de calibración sin firma y sello carece de validez.

Fecha de Emisión	Jefe del Laboratorio de Metrología	Sello
2022-02-05	MANUEL ALEJANDRO ALIAGA TORRES	CALIBRATEC S.A.C. LABORATORIO PERU

Área de Metrología
Laboratorio de Presión

CERTIFICADO DE CALIBRACIÓN
CA- LP - 014 - 2022

6. Método de Calibración

La calibración ha sido realizada por el método de comparación directa entre las indicaciones de lectura del manómetro de deformación elástica y el manómetro patrón tomando como referencia el método descrito en la norma ASTM C 231-04 *"Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method"* y el documento INDECOPI/SNM PC - 004: 2012 *"Procedimiento de calibración de manómetros, vacuómetros y manovacuometros de deformación elástica"*.

7. Lugar de calibración

En el laboratorio de Presion de CALIBRATEC S.A.C.
Avenida Chillon Lote 50 B - Comas - Lima

8. Condiciones Ambientales

	Inicial	Final
Temperatura	21.6 °C	21.6 °C
Humedad Relativa	65 % HR	65 % HR

9. Patrones de Referencia

Trazabilidad	Patrón utilizado	Certificado de calibración
ELICROM	Manómetro Digital con Incertidumbre 0.15	CCP-1315-001-21
METROIL	TERMOHIGROMETRO DIGITAL BOECO	T-1774-2021

CALIBRATEC S.A.C. LABORATORIO PERU

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10. Resultados de Medición

Medidor de Aire tipo Bourdon					
Indicación A Calibrar (psi)	Indicación Manómetro Patrón		Error de Indicación		de Histeresis (psi)
	Ascendente (psi)	Descendente (psi)	Ascendente (psi)	Descendente (psi)	
0	0.0	0.0	0.0	0.0	0.0
5	5.1	5.1	-0.1	0.0	0.0
10	10.1	10.1	-0.1	-0.3	-0.2
15	15.1	14.8	-0.2	-0.3	-0.1

Ensayo de Contenido de Aire (%)					
% De Aire	Indicación del Manómetro			Promedio	Error (%)
5.0	5.00	5.00	5.00	5.00	0.00
10.0	10.00	10.00	10.00	10.00	0.00
15.0	15.20	15.20	15.20	15.20	0.20
20.0	20.20	20.20	20.20	20.20	0.20
30.0	30.30	30.30	30.30	30.30	0.30
50.0	50.35	50.35	50.35	50.35	0.35
100.0	100.00	100.00	100.00	100.00	0.00
				Error Máximo Permitido (EMP)	1.0 (%)

Nota 1.- El punto inicial se determinó en 100%, para obtener el cero.

CALIBRATEC S.A.C. LABORATORIO PERU

11. Observaciones

- (*) Serie grabado en el instrumento.
- Se colocó una etiqueta autoadhesiva con la indicación **CALIBRADO.**
- La densidad en el lugar de calibración es de 1.184 kg/m³

12. Incertidumbre

La incertidumbre expandidad de medición se ha obtenido multiplicando la incertidumbre estándar de la medición por el factor de cobertura k=2, el cual corresponde a una probabilidad de cobertura de aproximadamente 95%.
La incertidumbre expandida de medición fue calculada a partir de los componentes de incertidumbre de los factores de influencia en la calibración. La incertidumbre indicada no incluye una estimación de variaciones a largo plazo.

CERTIFICADO DE CALIBRACIÓN EP-001196

Expediente : 077-2023
Fecha de emisión : 2023 - 05 - 16

1. **SOLICITANTE** : **GEOCONTROL TOTAL E.I.R.L.**

DIRECCIÓN : AV. CIRCUNVALACION NORTE NRO. 1728 (FRENTE AL EX OVALO SALIDA AL CUSCO) PUNO - SAN ROMAN - JULIACA

2. **INSTRUMENTO DE MEDICIÓN** : **MANÓMETRO DE DEFORMACIÓN ELÁSTICA**

MARCA : WEIZZ
MODELO : EN-837-1
N° DE SERIE : 12010631
INTERVALO DE INDICACIÓN : 0 psi a 400 psi / 0 bar a 28 bar
RESOLUCIÓN : 10 psi / 0.5 bar
DIÁMETRO DE ROSCA : 1/4 " NPT
DIÁMETRO DE CAJA : 63 MM
IDENTIFICACIÓN : EP-001196
UBICACIÓN : NO INDICA
CLASE DE EXACTITUD : 1.60

3. **LUGAR DE CALIBRACIÓN** : INSTALACIONES DE EVALÚA PERU S.A.C.

4. **FECHA DE CALIBRACIÓN** : 2023 - 05 - 16

5. **CONDICIONES AMBIENTALES.**

MAGNITUD		INICIAL	FINAL
TEMPERATURA (°C)	:	27.5	27.5
HUMEDAD RELATIVA	:	57%	57%

6. **MÉTODO.**

La calibración se realizó tomando como referencia el **"Procedimiento PC-004: Procedimiento para la calibración de instrumentos de medición de presión relativa con clase de exactitud igual o mayor a 0,05 % F.S."**.

7. **PATRÓN DE MEDICIÓN.**

Se usó patrones trazables a las unidades de presión, temperatura y humedad, calibrados por el Instituto Nacional de Calidad INACAL-DM.

Instrumento patrón	Div. de escala / Resolución	Clase de exactitud	N° de Certificado y/o Informe
Manómetro de indicación Digital (50 bar)	0.005 bar	0.05 % F.S.	LFP-022-2023 INACAL-DM

Este certificado refleja los resultados obtenidos en la fecha que fueron realizadas todas las mediciones y en las condiciones que se practicaron.

EL LABORATORIO METROLOGICO EVALÚA PERU S.A.C. no se hace responsable de los perjuicios que puedan producirse debido al uso inadecuado de los instrumentos calibrados.

Este certificado de calibración documenta la trazabilidad a los patrones nacionales o internacionales, de acuerdo con el Sistema Internacional de Unidades (SI).

EL LABORATORIO METROLOGICO EVALÚA PERU S.A.C no se responzabilizara del uso inadecuado del presente documento.

SERVICIO ASEGURAMIENTO METROLÓGICO EVALÚA PERÚ S.A.C. EVALÚA PERU S.A.C.

Edguar Saldaña Salas
Gerente Técnico

COPIA NO CONTROLADA
GEOCONTROL TOTAL E.I.R.L.
LABORATORIO DE SUELOS Y CONCRETO

Certificado N° : EP-001196

PROHIBIDA LA REPRODUCCIÓN TOTAL O PARCIAL DE ESTE DOCUMENTO SIN LA AUTORIZACIÓN DEL LABORATORIO EVALÚA PERÚ S.A.C.

8. OBSERVACIONES.

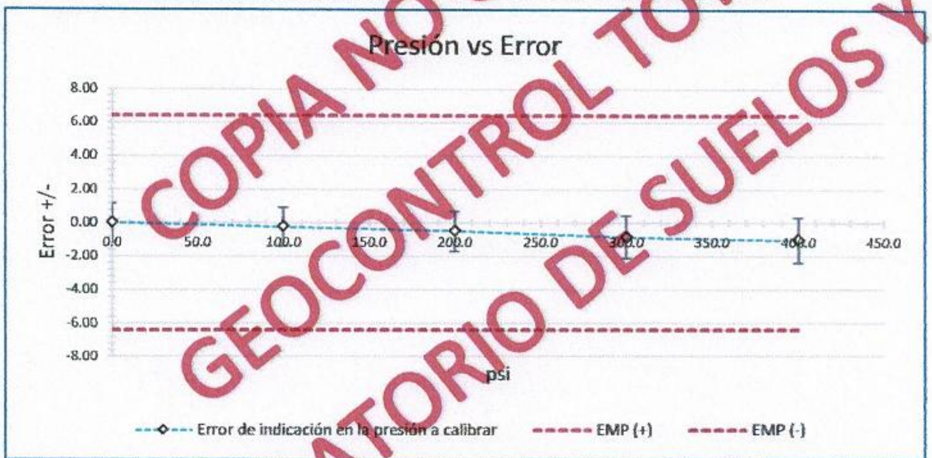
La incertidumbre de la medición se determinó con un factor de cobertura k=2, para un nivel de confianza de 95 %.
Con fines de identificación de la calibración se colocó una etiqueta autoadhesiva.
La periodicidad de la calibración depende del uso, mantenimiento y conservación del instrumento de medición.

9. RESULTADOS.

Indicación Equipo a calibrar		Error de Indicación	Error de Histéresis	Incertidumbre
kPa	psi	psi	psi	psi
0.0	0.0	0.00	0.00	1.16
689.5	100.0	-0.24	-0.15	1.17
1379.0	200.0	-0.50	-0.30	1.21
2068.4	300.0	-0.85	-0.45	1.28
2757.9	400.0	-1.05	-0.61	1.36

Máximo Error absoluto de Indicación	:	1.05	psi
Máximo Error absoluto de Histéresis	:	0.61	psi

El error máximo permitido para manómetros de 0 psi a 400 psi, de clase de exactitud : 1.6 es de ± 6.40 psi



E.M.P. : Error máximo permitido

FIN DEL DOCUMENTO

COPIA NO CONTROLADA
GEOCONTROL TOTAL E.I.R.L.
LABORATORIO DE SUELOS Y CONCRETO

PROHIBIDA LA REPRODUCCIÓN TOTAL O PARCIAL DE ESTE DOCUMENTO SIN LA AUTORIZACIÓN DEL LABORATORIO EVALÚA PERÚ S.A.C.

Anexo N.°13: Análisis de costo unitario de concreto para pavimentos rígido

Tabla 1

Análisis de costo por metro cúbico concreto patrón

01.01	**Concreto f'c=280 kg/cm^2 p/losas (concreto patrón)**					
Rendimiento:	**15 m^3/día**		**Costo unitario por m^3**			**421.20**
Descripción recurso		**Unidad**	**Cuadrilla**	**Cantidad**	**Precio S/.**	**Parcial S/.**
Mano de obra						**134.16**
Operario		hh	2.0000	1.0667	23.44	25.00
Oficial		hh	2.0000	1.0667	18.53	19.77
Peón		hh	10.0000	5.3333	16.76	89.39
Materiales						**267.61**
Piedra chancada 3/4"		m3		0.3454	70.00	24.18
Arena gruesa		m3		0.2942	45.00	13.24
Agua puesta en obra		m3		0.1930	1.00	0.19
Cemento portland tipo ip (42.5 kg)		bol		10.0000	23.00	230.00
Equipos						**19.43**
Herramientas manuales		%mo		3.0000	134.16	4.02
Mezcladora de concreto 9-11p3		hm	1.0000	0.5333	22.00	11.73
Vibrador de concreto 4 hp 1.35"		hm	1.0000	0.5333	6.90	3.68

Tabla 2

Análisis de costo por metro cúbico concreto patrón + 1% MCC

01.02	**concreto f'c=280 kg/cm^2 p/losas (concreto patrón+1%MCC)**					
Rendimiento:	**15 m^3/día**		**Costo unitario por m^3**			**474.46**
Descripción recurso		**Unidad**	**Cuadrilla**	**Cantidad**	**Precio S/.**	**Parcial S/.**
Mano de obra						**134.16**
Operario		hh	2.0000	1.0667	23.44	25.00
Oficial		hh	2.0000	1.0667	18.53	19.77
Peón		hh	10.0000	5.3333	16.76	89.39
Materiales						**266.88**
Piedra chancada 3/4"		m3		0.3240	70.00	22.68
Arena gruesa		m3		0.3113	45.00	14.01
Agua puesta en obra		m3		0.1930	1.00	0.19
Cemento portland tipo IP (42.5 kg)		bol		10.0000	23.00	230.00
Equipos						**22.12**
Herramientas manuales		%mo		5.0000	134.16	6.71

Mezcladora de concreto 9-11p3	hm	1.0000	0.5333	22.00	11.73
Vibrador de concreto 4 hp 1.35"	hm	1.0000	0.5333	6.90	3.68
Subpartidas					**51.30**
Extracción y procesamiento de Mucílago de *cactaceae* columnar	L		4.25	12.07	51.30

Tabla 3

Análisis de costo por metro cúbico concreto patrón + 2% MCC

01.03	**Concreto f'c=280 kg/cm^2 p/losas (concreto patrón+2%MCC)**				
Rendimiento: **15 m^3/día**		**Costo unitario por m^3**			**525.52**
Descripción recurso	**Unidad**	**Cuadrilla**	**Cantidad**	**Precio S/.**	**Parcial S/.**
Mano de obra					**134.16**
Operario	hh	2.0000	1.0667	23.44	25.00
Oficial	hh	2.0000	1.0667	18.53	19.77
Peón	hh	10.0000	5.3333	16.76	89.39
Materiales					**266.64**
Piedra chancada 3/4"	m3		0.3219	70.00	22.53
Arena gruesa	m3		0.3093	45.00	13.92
Agua puesta en obra	m3		0.1930	1.00	0.19
Cemento portland tipo IP (42.5 kg)	bol		10.0000	23.00	230.00
Equipos					**22.12**
Herramientas manuales	%mo		5.0000	134.16	6.71
Mezcladora de concreto 9-11p3	hm	1.0000	0.5333	22.00	11.73
Vibrador de concreto 4 hp 1.35"	hm	1.0000	0.5333	6.90	3.68
Subpartidas					**102.60**
Extracción y Procesamiento de Mucílago de *cactaceae* columnar	L		8.5000	12.07	102.60

Tabla 4

Análisis de costo por metro cúbico concreto patrón + 3% MCC

01.04	**Concreto f'c=280 kg/cm^2 p/losas (concreto patrón+3%MCC)**				
Rendimiento: **15 m^3/día**		**Costo unitario por m3**			**577.13**
Descripción recurso	**Unidad**	**Cuadrilla**	**Cantidad**	**Precio S/.**	**Parcial S/.**
Mano de obra					**134.16**
Operario	hh	2.0000	1.0667	23.44	25.00
Oficial	hh	2.0000	1.0667	18.53	19.77
Peón	hh	10.0000	5.3333	16.76	89.39

01.04	Concreto f'c=280 kg/cm² p/losas (concreto patrón+3%MCC)				
Rendimiento: 15 m^3/día		Costo unitario por m3			577.13
Descripción recurso	Unidad	Cuadrilla	Cantidad	Precio S/.	Parcial S/.
Materiales					**266.96**
Piedra chancada 3/4"	m3		0.3197	70.00	22.38
Arena gruesa	m3		0.3197	45.00	14.39
Agua puesta en obra	m3		0.1930	1.00	0.19
Cemento portland tipo IP (42.5 kg)	bol		10.0000	23.00	230.00
Equipos					**22.12**
Herramientas manuales	%mo		5.0000	134.16	6.71
Mezcladora de concreto 9-11p3	hm	1.0000	0.5333	22.00	11.73
Vibrador de concreto 4 hp 1.35"	hm	1.0000	0.5333	6.90	3.68
Subpartidas					**153.89**
Extracción y procesamiento de mucílago de *cactaceae* columnar	L		12.75	12.07	153.89

Fuente. Elaboración propia.

Tabla 5

Análisis de costo por estimado de extracción y procesamiento de MCC

01.04	Extracción y procesamiento de mucílago de cactus columnar				
Rendimiento: 20 L/dia		Costo unitario por L			12.07
Descripción recurso	Unidad	Cuadrilla	Cantidad	Precio S/.	Parcial S/.
Mano de obra					**7.64**
Operario	hh	0.100	0.0400	23.44	0.94
Peon	hh	1.000	0.4000	16.76	6.70
Materiales					**3.00**
Planta Mucílago de cactaceae columnar	kg		3.000	1.00	3.00
Equipos					**1.43**
Herramientas manuales	%mo		3.0000	7.64	0.23
Equipo extractor de mucílago	hm	1.0000	0.4000	3.00	1.20

Nota. Este análisis de costo se realizó en base a la ejecución de esta investigación.

Fuente. Elaboración propia.

Anexo No. 14: Panel Fotográfico

PANEL FOTOGRAFICO

***Ilustración 1**.Cantera Jeservi de agregado fino*

***Ilustración 2**. Cantera Jeservi de agregado Grueso*

Ilustración 3*. Lugar de extraccion de Cactaceae*

Ilustración 4*. Pesado del mucilago de cactaceae para determinar el peso especifico*

***Ilustración 5**. Cuarteo deagregado fino ASTM C29 / C29M – 17ª*

***Ilustración 6**. Peso unitario suelto de Agregado grueso ASTM C29 / C29M – 17a*

Ilustración 7. *Prueba de absorcion de Agregados gruesos ASMT C127-15*

Ilustración 8. *Cuarteo de agregado grueso ASTM C29 / C29M – 17a*

Ilustración 9.*pesado de cemento*

Ilustración 10*.pesado de mucilago de cactaceae*

Ilustración 11.*pesado de agregado grueso*

Ilustración 12.*Adición de MC natural a la mezcla*

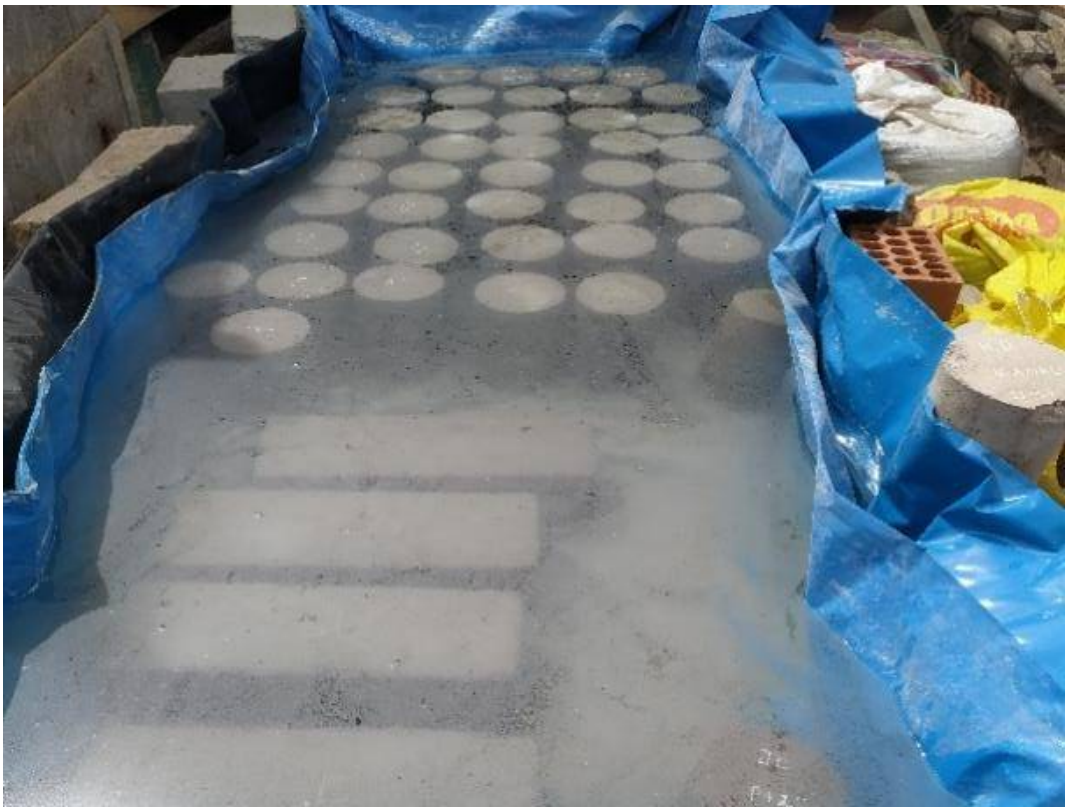


***Ilustración** 13.Curado de muestras cilíndricas y prismática*

***Ilustración 14**. Muestras para ensayo a compresión*

***Ilustración 15**. Verificación de tipo de rotura de acuerdo a la norma ASTM C39.*

***Ilustración 16**. Marcado de punto de apoyo donde se aplicarán las cargas en flexión de vigas*

Ilustración 17*.Verificacion de rotura en tercio central de viga prismática*

Ilustración 18*.Dispositivo para ensayo de profundidad de penetración de agua norma UNE-12390-8.*

Ilustración 19*.Manometro de deformación elástica para mantener la presión 500±50 Kpa de acuerdo a la norma UNE-12390-8.*

Ilustración 20*.Muestras después de ser sometidas a presión 500±50 Kpa durante 72±2 horas de acuerdo a la norma UNE-12390-8.*

Ilustración 21*. Partido de muestras para visualizar la profundidad de penetración de agua bajo presión.*

Ilustración 22. Medición de la profundidad de penetración maxima de agua bajo presión

***Ilustración 23**. Se muestra la profundidad de penetración de agua bajo presión.*

***Ilustración 24**. Se muestra la profundidad de penetración de agua bajo presión.*