ANEXOS

A-1: Constancia de laboratorio de construcciones.

UNIVERSIDAD NACIONAL DEL ALTIPLANO
ESCUELA PROFESIONAL DE INGENIERÍA CIVIL
LABORATORIO DE CONSTRUCCIONES

ESCUELA PROFESIONAL DE INGENIERÍA CIVIL

<u>CONSTANCIA DE USO DE EQUIPOS Y LABORATORIO DE CONSTRUCCIONES</u>

EL QUE SUSCRIBE JEFE DE LABORATORIO DE CONSTRUCCIONES DE LA FICA

<u>Hace Constar:</u>

QUE EL TESISTA, conducente a la obtención del Título Profesional de Ingeniero Civil Bach: ALAN ADERLY MACHACA AROCUTIPA, hizo uso de los equipos del Laboratorio de Construcciones – FICA, para realizar los ensayos requeridos para su proyecto de Tesis: " **INFLUENCIA DE LA PRE HIDRATACION Y DEL ADITIVO SUPERPLASTIFICANTE EN LA TRABAJABILIDAD Y RESISTENCIA A LA COPRESION DEL CONCRETO ELABORADO CON CEMENTOS ALMACENADOS POR MAS DE 6 MESES."**

Los ensayos que realizo son los siguientes:

ITEM	ENSAYOS	NRO. DE ENSAYOS	FECHA DE ENSAYO
1	CONTENIDO DE HUMEDAD DE LOS AGREGADOS: FINO Y GRUESO	1	25/09/2019
2	ANALISIS GRANULOMÉTRICO DE LOS AGREGADOS FINO Y GRUESO.	1	24/07/2019
3	DENSIDAD (PESO UNITARIO) DE LOS AGREGADOS, SUELTO Y COMPACTADO: FINO Y GRUESO.	1	24/07/2019
4	PESO ESPECÍFICO DE LOS AGREGADOS: FINO Y GRUESO.	1	24/07/2019
5	PORCENTAJE DE ABSORCIÓN DE LOS AGREGADOS: FINO Y GRUESO.	1	24/07/2019
6	ENSAYO DE COMPRESIÓN SIMPLE PARA PROBETAS DE CONCRETO.	420	17/10/2019 al 22/10/2019 18/10/2019 al 23/10/2019 24/10/2019 al 29/10/2019 25/10/2019 al 30/10/2019 07/11/2019 al 10/11/2019 08/11/2019 al 11/11/2019

Los resultados obtenidos, de los ensayos, no son responsabilidad del laboratorio de Construcciones.
Se le expide la siguiente constancia a solicitud escrita del interesado, para adjuntar en su proyecto de Tesis.

Puno, C.U. 20 de Diciembre del 2019

UNIVERSIDAD NACIONAL DEL ALTIPLANO
Msc. Ing. Gino F. Laque Córdova
JEFE DE LABORATORIO

A-2: Ensayos de Laboratorio.

Universidad Nacional del Altiplano
Facultad de Ingeniería Civil y Arquitectura
Laboratorio de Construcciones
Av. Jorge Basadre S/N (Ciudad Universitaria)

CONTENIDO DE HUMEDAD AGREGADOS FINO Y GRUESO

SOLICITANTE	:	TESISTA: ALAN ADERLY MACHACA AROCUTIPA
PROYECTO	:	INFLUENCIA DE LA PRE HIDRATACION Y DEL ADITIVO SUPERPLASTIFICANTE EN LA TRABAJABILIDAD Y RESISTENCIA A LA COPRESION DEL CONCRETO ELABORADO CON CEMENTOS ALMACENADOS POR MAS DE 6 MESES.
UBICACIÓN	:	PUNO-PUNO
MUESTRA	:	CANTERA: WILUYO
DISEÑO	:	a/c = 0.55, 0.65 y 0.75
FECHA	:	24 DE JULIO DEL 2019

AGREGADO FINO

Nro De Tara	**B-8**	**S-03**	**S-01**
Peso de Tara	29.82	50.68	50.65
Peso de Tara + M. Humeda	529.05	664.78	550.57
Peso de Tara + M. Seca	509.93	653.89	537.08
Peso de Agua	19.12	10.89	13.49
Peso Muestra Seca	480.11	603.21	486.43
Contenido de humedad W%	3.98	1.81	2.77
Promedio cont. Humedad W%		**2.85**	

AGREGADO GRUESO

Nro De Tara	**B-9**	**S-02**	**B-11**
Peso de Tara	29.18	51.31	32.38
Peso de Tara + M. Humeda	574.76	737.48	689.83
Peso de Tara + M. Seca	566.86	729.25	680.01
Peso de Agua	7.9	8.23	9.82
Peso Muestra Seca	537.68	677.94	647.63
Contenido de humedad W%	1.47	1.21	1.52
Promedio cont. Humedad W%		**1.40**	

Universidad Nacional del Altiplano
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Laboratorio de Construcciones
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PESO ESPECIFICO UNITARIO

AGREGADOS FINO Y GRUESO

SOLICITANTE	:	TESISTA: ALAN ADERLY MACHACA AROCUTIPA
PROYECTO	:	INFLUENCIA DE LA PRE HIDRATACION Y DEL ADITIVO SUPERPLASTIFICANTE EN LA TRABAJABILIDAD Y RESISTENCIA A LA COPRESION DEL CONCRETO ELABORADO CON CEMENTOS ALMACENADOS POR MAS DE 6 MESES.
UBICACIÓN	:	PUNO-PUNO
MUESTRA	:	CANTERA: WILUYO
DISEÑO	:	a/c = 0.55, 0.65 y 0.75
FECHA	:	24 DE JULIO DEL 2019

AGREGADO FINO

PESO UNITARIO SUELTO

MOLDE NRO.	I	II	III
PESO DEL MOLDE gr.	10025.000	10025.000	10025.000
PESO MOLDE + MUESTRA gr.	18835.000	18845.000	18900.000
PESO DE LA MUESTRA gr.	8810.000	8820.000	8875.000
VOLUMEN DEL MOLDE cm3,	5377.437	5377.437	5377.437
PESO UNITARIO Gr/Cm3,	1.638	1.640	1.650
PESO UNITARIO HUMEDO KG/M3,		1643	
PESO UNITARIO SECO KG/M3,		1643	

PESO UNITARIO COMPACTADO

MOLDE NRO.	I	II	III
PESO DEL MOLDE gr.	10025.000	10025.000	10025.000
PESO MOLDE + MUESTRA gr.	19500.000	19550.000	19535.000
PESO DE LA MUESTRA gr.	9475.000	9525.000	9510.000
VOLUMEN DEL MOLDE cm3	5377.437	5377.437	5377.437
PESO UNITARIO Gr/Cm3	1.762	1.771	1.769
PESO UNITARIO HUMEDO KG/M3		1767	
PESO UNITARIO SECO KG/M3,		1767	

AGREGADO GRUESO

PESO UNITARIO SUELTO

MOLDE NRO.	I	II	III
PESO DEL MOLDE gr.	10025.000	10025.000	10025.000
PESO MOLDE + MUESTRA gr.	18260.000	18260.000	18200.000
PESO DE LA MUESTRA gr.	8235.000	8235.000	8175.000
VOLUMEN DEL MOLDE cm3	5377.437	5377.437	5377.437
PESO UNITARIO Gr/Cm3	1.531	1.531	1.520
PESO UNITARIO HUMEDO KG/M3		1528	
PESO UNITARIO SECO KG/M3,		1528	

PESO UNITARIO COMPACTADO

MOLDE NRO.	I	II	III
PESO DEL MOLDE gr.	10025.000	10025.000	10025.000
PESO MOLDE + MUESTRA gr.	19280.000	19075.000	19150.000
PESO DE LA MUESTRA gr.	9255.000	9050.000	9125.000
VOLUMEN DEL MOLDE cm3	5377.437	5377.437	5377.437
PESO UNITARIO Gr/Cm3	1.721	1.683	1.697
PESO UNITARIO HUMEDO KG/M3		1700	
PESO UNITARIO SECO KG/M3,		1700	

Universidad Nacional del Altiplano
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PESO ESPECIFICO Y ABSORCIÓN
AGREGADOS FINO Y GRUESO PARA DISEÑO DE MEZCLAS

SOLICITANTE	:	TESISTA: ALAN ADERLY MACHACA AROCUTIPA
PROYECTO	:	INFLUENCIA DE LA PRE HIDRATACION Y DEL ADITIVO SUPERPLASTIFICANTE EN LA TRABAJABILIDAD Y RESISTENCIA A LA COPRESION DEL CONCRETO ELABORADO CON CEMENTOS ALMACENADOS
UBICACIÓN	:	PUNO-PUNO
MUESTRA	:	CANTERA: WILUYO
DISEÑO	:	a/c = 0.55, 0.65 y 0.75
FECHA	:	24 DE JULIO DEL 2019

PESO ESPECIFICO Y ABSORCION DE AGREGADO FINO

I.- DATOS

S	PESO DE LA MUESTRA DE ARENA SUPERFICIALMENTE SECA	500.00
B	PESO DEL PICNOMETRO +PESO DEL AGUA	708.61
C	PESO DE LA ARENA SUPERFICIALMENTE SECA+PESO DEL PICNOMETRO+PESO DEL AGUA	1020.80
A	PESO DE LA ARENA SECADA AL HORNO	480.78

II.- RESULTADOS

1	PESO ESPECIFICO APARENTE (A/(B+S-C))	2.56
2	PESO ESPECIFICO APARENTE (SSS)	2.66
3	PORCENTAJE DE ABSORCION: %ABS((S-A)/A)	4.00

PESO ESPECIFICO Y ABSORCION DE AGREGADO GRUESO

I.- DATOS

A	PESO DE LA MUESTRA SECADA AL HORNO GR.	1970.31
S	PESO DE LA MUESTRA SATURADA SUPERFICIALMENTE SECA GR.	2000.00
	PESO DE LA CANASTILLA SUMERGIDA	141.08
	PESO DE LA CANASTILLA SUMERGIDA + MUESTRA SSS SUMERGIDA	1361.55
C	PESO DE LA MUESTRA SATURADA SUPERFICIALMENTE SECA SUMERGIDA EN AGUA	1220.47

II.- RESULTADOS

1	PESO ESPECIFICO APARENTE (A/(S-C))	2.52756
2	PESO ESPECIFICO APARENTE (SSS)	2.57
3	PORCENTAJE DE ABSORCION: %ABS(S-A)/A)	1.51

Universidad Nacional del Altiplano
Facultad de Ingeniería Civil y Arquitectura
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Av. Jorge Basadre S/N (Ciudad Universitaria)

ANALISIS GRANULOMETRICO POR TAMIZADO (ASTM D422)

ENSAYOS ESTANDAR DE CLASIFICACION (D2216 - D854 - D4318 - D427 - D2487)

TAMICES ASTM	ABERTURA mm	PESO RETENIDO	%RETENIDO PARCIAL	%RETENIDO ACUMULADO	% QUE PASA	ESPECIF. ASTM	
3"	76.200						
2 1/2"	63.500						
2"	50.600						
1 1/2"	38.100						
1"	25.400						
3/4"	19.050						
1/2"	12.700						
3/8"	9.525						**100**
1/4"	6.350						
No4	4.760	0.31	0.06	0.06	**99.94**	**95**	**100**
No8	2.380	86.85	17.39	17.45	**82.55**	**80**	**100**
No10	2.000						
No16	1.190	79.72	15.96	33.41	**66.59**	**50**	**85**
No20	0.840						
No30	0.590	113.92	22.81	56.21	**43.79**	**25**	**60**
No40	0.420						
No50	0.300	162.73	32.58	88.79	**11.21**	**10**	**30**
No60	0.250						
No80	0.180						
No100	0.149	44.62	8.93	97.72	**2.28**	**2**	**10**
No200	0.074	7.34	1.47	99.19	**0.81**		
BASE		4.03	0.81	100.00	0.00		
TOTAL		499.52	100.00				
% PERDIDA		0.096%					

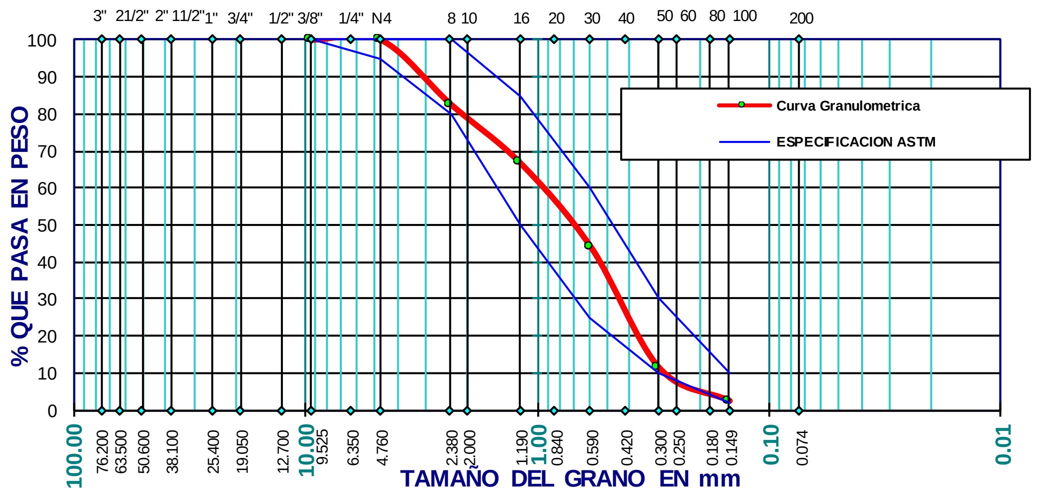
DESCRIPCION DE LA MUESTRA

P.L.
P.S. 500.00

MODULO DE FINEZA : 2.94

El modulo de fineza debe de estar dentro de los limites de 2.35 - 3.15, no debiendo excederse el limite en mas o menos 0.2 Max 3.35

CURVA GRANULOMETRICA



Universidad Nacional del Altiplano
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ANALISIS GRANULOMETRICO POR TAMIZADO (ASTM D422)

ENSAYOS ESTANDAR DE CLASIFICACION (D2216 - D854 - D4318 - D427 - D2487)

TAMICES ASTM	ABERTURA mm	PESO RETENIDO	%RETENIDO PARCIAL	%RETENIDO ACUMULADO	% QUE PASA	ESPECIF. ASTM C-33	
3"	76.200						
2 1/2"	63.500						
2"	50.600						
1 1/2"	38.100	0.00	0.00	0.00	**100.00**	**100**	**100**
1"	25.400	1800.00	18.00	18.00	**82.00**	**95**	**100**
3/4"	19.050	1930.00	19.30	37.30	**62.70**		**100**
1/2"	12.700	2820.00	28.20	65.50	**34.50**	**25**	**60**
3/8"	9.525	1360.00	13.60	79.10	**20.90**		
1/4"	6.350						
No4	4.760	2045.00	20.45	99.55	**0.45**	**0**	**10**
No8	2.380						
No10	2.000						
No16	1.190						
No20	0.840						
No30	0.590						
No40	0.420						
No50	0.300						
No60	0.250						
No80	0.180						
No100	0.149						
No200	0.074						
BASE		45.00	0.45	100.00	0.00		
TOTAL		10000.00	100.00				
% PERDIDA		0.000					

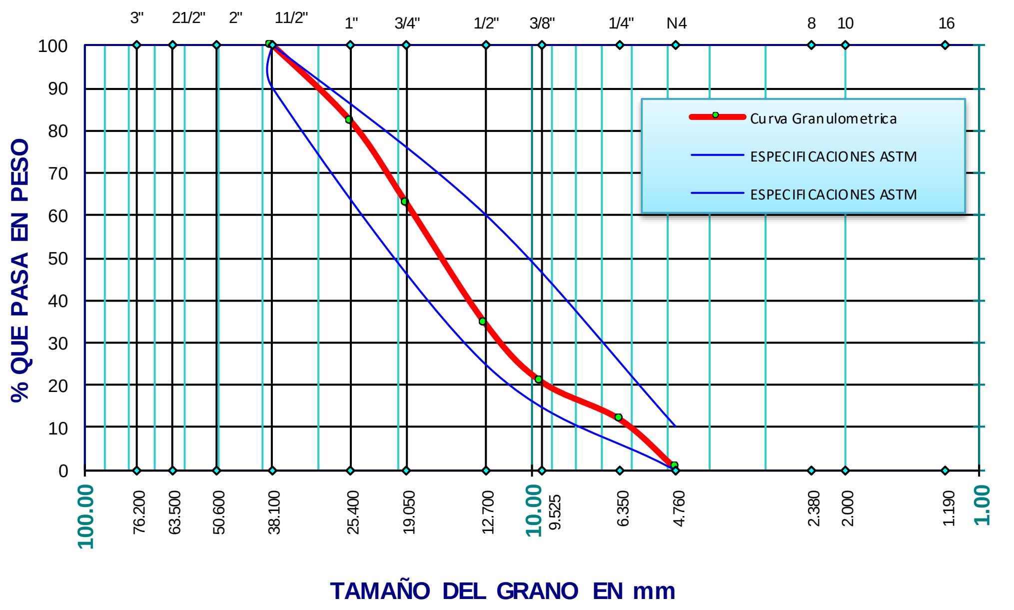
TAMAÑO MAXIMO: 1 1/2"
ESCRIP. DE LA MUESTRA

P.M 10000.00
P.I 10000.00

MODULO DE FINEZA : **7.16**

OBS: TAMIZAR POR LA MALLA Nº 4 PARA SEPARAR EL AG. GRUESO Y FINO

CURVA GRANULOMETRICA



A-3 CERTIFICADOS HOJA TECNICA

BUILDING TRUST

HOJA TÉCNICA
Sikament®-290N

Aditivo Polifuncional para Concreto

DESCRIPCIÓN DEL PRODUCTO

Sikament®-290N es un aditivo polifuncional para concretos que puede ser empleado como plastificante o superplastificante según la dosificación utilizada.

Muy adecuado para plantas de concreto al obtener con un único aditivo dos efectos diferentes sólo por la variación de la proporción del mismo.

Sikament®-290N no contiene cloruros y no ejerce ninguna acción corrosiva sobre las armaduras.

USOS

Sikament®-290N está particularmente indicado para:

Todo tipo de concretos fabricados en plantas concreteras con la ventaja

de poder utilizarse como plastificante o superplastificante con sólo variar la dosificación.

En concretos bombeados porque permite obtener consistencias adecuadas sin aumentar la relación agua/cemento.

Transporte a largas distancias sin pérdidas de trabajabilidad.

Concretos fluidos que no presentan segregación ni exudación.

CARACTERÍSTICAS / VENTAJAS

- Aumento de las resistencias mecánicas.
- Terminación superficial de alta calidad.
- Mayor adherencia a las armaduras.
- Permite obtener mayores tiempos de manejabilidad de la mezcla a cualquier temperatura.
- Permite reducir hasta el 25% del agua de la mezcla.
- Aumenta considerablemente la impermeabilidad y durabilidad del concreto.
- Facilita el bombeo del concreto a mayores distancias y alturas.

- Proporciona una gran manejabilidad de la mezcla evitando segregación y la formación de cangrejeras.
- Reductor de agua.

NORMAS

Como plastificante cumple con la Norma ASTM C 494, tipo D y como

superplastificante con la Norma ASTM C 494, tipo G.

DATOS BÁSICOS

FORMA

ASPECTO
Líquido

COLOR
Pardo oscuro.

PRESENTACIÓN
Cilindro x 200 L
Balde x 20 L
Dispenser x 1000 L
Granel x 1L

ALMACENAMIENTO

CONDICIONES DE ALMACENAMIENTO / VIDA ÚTIL

Un año en su envase original bien cerrado y bajo techo en lugar fresco resguardado de heladas. Para el transporte debe tomarse las precauciones normales para el manejo de un producto químico.

DATOS TÉCNICOS

DENSIDAD
1,20 kg/L +/- 0,02
USGBC VALORACIÓN LEED

Sikament® -290 N cumple con los requerimientos LEED.
Conforme con el LEED V3 IEQc 4.1 Low-emitting materials - adhesives and sealants.

Contenido de VOC < 420 g/L (menos agua)

INFORMACIÓN DEL SISTEMA

DETALLES DE APLICACIÓN

CONSUMO / DOSIS

Como plastificante: del 0,3 % – 0,7 % del peso del cemento.

Como superplastificante: del 0,7 % - 1,4 % del peso del cemento.

MÉTODO DE APLICACIÓN

MÉTODO DE APLICACIÓN

Como Plastificante.

Debe incorporarse junto con el agua de amasado.

Como Superplastificante.

Debe incorporarse preferentemente una vez amasado el concreto y haciendo un re-amasado de al menos 1 minuto por cada m3 de carga de la amasadora o camión concretero.

INSTRUCCIONES DE SEGURIDAD

PRECAUCIONES DURANTE LA MANIPULACION

Durante la manipulación de cualquier producto químico, evite el contacto directo con los ojos, piel y vías respiratorias. Protéjase adecuadamente utilizando guantes de goma natural o sintética y anteojos de seguridad.

En caso de contacto con los ojos, lavar inmediatamente con abundante agua durante 15 minutos manteniendo los párpados abiertos y consultar a su médico.

OBSERVACIONES

La Hoja de Seguridad de este producto se encuentra a disposición del interesado. Agradeceremos solicitarla a nuestro Departamento Comercial, teléfono: 618-6060 o descargarla a través de Internet en nuestra página web: www.sika.com.pe

NOTAS LEGALES

La información y en particular las recomendaciones sobre la aplicación y el uso final de los productos Sika son proporcionadas de buena fe, en base al conocimiento y experiencia actuales en Sika respecto a sus productos, siempre y cuando éstos sean adecuadamente almacenados, manipulados y transportados; así como aplicados en condiciones normales. En la práctica, las diferencias en los materiales, sustratos y condiciones de la obra en donde se aplicarán los productos Sika son tan particulares que de esta información, de alguna recomendación escrita o de algún asesoramiento técnico, no se puede deducir ninguna garantía respecto a la comercialización o adaptabilidad del producto a una finalidad particular, así como ninguna responsabilidad contractual. Los derechos de propiedad de las terceras partes deben ser respetados.

Todos los pedidos aceptados por Sika Perú S.A. están sujetos a Cláusulas Generales de Contratación para la Venta de Productos de Sika Perú S.A. Los usuarios siempre deben remitirse a la última edición de la Hojas Técnicas de los productos; cuyas copias se entregarán a solicitud del interesado o a las que pueden acceder en Internet a través de nuestra página web www.sika.com.pe.

"La presente Edición anula y reemplaza la Edición Nº 10

la misma que deberá ser destruida"

CEMENTO PORTLAND PUZOLÁNICO FRONTERA IP – ULTRA FUERTE

DESCRIPCIÓN

El Cemento Portland Puzolánico FRONTERA IP, ULTRA FUERTE, es un cemento elaborado con Clinker de alta calidad, yeso y adiciones. Su fabricación es realizada bajo un sistema de gestión de calidad certificado con ISO 9001 y de gestión ambiental ISO 14001, lo que garantiza un alto estándar de calidad. Cumple con la Norma Técnica Peruana NTP 334.090 y Norma Americana ASTM C595

Este cemento es Ecoamigable, debido a que en su producción se reduce ostensiblemente la emisión de CO2, colaborando de esta manera con el medio ambiente, en la disminución de los gases con efecto invernadero.

Los componentes especiales del cemento FRONTERA IP, ULTRAFUERTE, otorgan a los concretos y morteros propiedades especiales que lo hacen resistente a los ataques químicos (aguas saladas, sulfatadas, ácidas, desechos industriales, reacciones químicas en los agregados, etc.) y a las acciones del intemperismo. Puede ser utilizado en cualquier tipo de obras de infraestructura y construcción en general.

CARACTERÍSTICAS TÉCNICAS

REQUISITOS QUÍMICOS	CEMENTO PORTLAND PUZOLÁNICO FRONTERA IP	Requisitos Norma NTP 334.090 ASTM C-595
MgO (%)	1.99	6.00 Máx.
SO_3 (%)	1.75	4.00 Máx.
Pérdida por ignición (%)	2.14	5.00 Máx.

REQUISITOS FÍSICOS	CEMENTO PORTLAND PUZOLÁNICO FRONTERA IP		Norma NTP 334.090 ASTM C-595	
Peso especifico (gr/cm3)	2.85		-	
Expansión en autoclave (%)	0		0.80 Máx.	
Fraguado Vicat inicial (minutos)	170		45 Mín.	
Fraguado Vicat final (minutos)	270		420 Máx.	
Resistencia a la compresión	Kgf/cm²	MPa	Kgf/cm²	MPa
1 días	97	9	-	-
3 días	194	19	133 Mín.	13
7 días	241	23	204 Mín.	20
28 días	330	32	255 Mín.	25
Resistencia a los sulfatos	Cemento IP			
% Expansión a los 14 días	0.018		-	

PROPIEDADES

- Alta resistencia a la compresión
- Resistencia a los sulfatos
- Resistencia a los cloruros
- Menor calor de hidratación
- Inhibe la reacción nociva álcali-agregado
- Aumento de impermeabilidad
- Mayor plasticidad y trabajabilidad en concretos y morteros

BENEFICIOS AMBIENTALES

Menor consumo energético.
Cemento fabricado con menor emisión de CO_2.

CEMENTO PORTLAND PUZOLÁNICO
FRONTERA IP – ULTRA FUERTE

RECOMENDACIONES DE SEGURIDAD

- El contacto con este producto provoca irritación cutánea e irritación ocular grave, evite el contacto directo en piel y mucosas.
- En caso de contacto con los ojos, lavar con abundante agua limpia.
- En caso de contacto con la piel, lavar con agua y jabón.
- Para su manipulación es obligatorio el uso de los siguientes elementos de protección:

Guantes Impermeables | Protección Ocular | Botas Impermeables | Protección Respiratoria

ALMACENAMIENTO

Para mantener el cemento en óptimas condiciones, se recomienda:

- Almacenar en un ambiente seco, separado del suelo y de las paredes.
- Protegerlos contra la humedad o corriente de aire húmedo.
- En caso de almacenamiento prolongado, cubrir el cemento con polietileno.
- No apilar más de 10 bolsas o en 2 pallet de altura.

PRESENTACIONES DISPONIBLES

- **Bolsas 42.5 Kg** Ideal para proyectos medianos y pequeños, o con accesos complicados y pocas áreas de almacenamiento.
- **Big Bag 1.0 TM** Para proyectos de constructoras que tienen planta de concreto. Facilita la manipulación de grandes volúmenes.
- **Big Bag 1.5 TM** Para proyectos mineros y de gran construcción, requiere la utilización de equipos de carga.

NORMAS TÉCNICAS

EL CEMENTO PORTLAND PUZOLÁNICO FRONTERA IP - ULTRA FUERTE, cumple con las especificaciones técnicas de los siguientes países:

PAIS	NORMA		DENOMINACIÓN	
Perú	Norma Técnica Peruana	NTP 334.090	CEMENTO PORTLAND PUZOLÁNICO	TIPO IP
Chile	Norma Chilena Oficial	NCh 148 Of68	CEMENTO PUZOLÁNICO	GRADO CORRIENTE

DURACIÓN

Almacenar y consumir de acuerdo a la fecha de producción utilizando el más antiguo. Se recomienda que el cemento sea utilizado antes de 60 días de la fecha de envasado indicada en la bolsa, luego de esa fecha, verifique la calidad del mismo.

PLANTA: Estación Yura Km 26 s/n, Yura, Arequipa - Perú
OFICINA COMERCIAL: Av. General Díez Canseco N° 527 - Arequipa
TELÉFONO: (054) 495060 - 225000 - **FAX:** (054) 220650

A-4 DATSO CLIMATOLOGICOS DE LA CIUDAD DE PUNO (SENAMHI/DRD)

Diciembre del 2018

Estación : PUNO

Departamento : PUNO | Provincia : PUNO | Distrito : PUNO

Latitud : 15°49'34.5'' | Longitud : 70°0'43.5'' | Altitud : 3812 msnm.

Tipo : EMA - Meteorológica | Código : 472DD33A

AÑO / MES / DÍA	HORA	TEMPERATURA (°C)	PRECIPITACIÓN (mm/hora)	HUMEDAD (%)	DIRECCION DEL VIENTO (°)	VELOCIDAD DEL VIENTO (m/s)
01/12/2018	08:00	S/D	S/D	S/D	S/D	S/D
02/12/2018	09:00	10.1	0	29	130	1.9
02/12/2018	10:00	S/D	0	S/D	123	2.6
02/12/2018	11:00	12.5	0	35	134	4
02/12/2018	12:00	14.1	0	33	35	3.1
02/12/2018	13:00	14.8	0	32	89	4.4
03/12/2018	08:00	S/D	0	S/D	69	5.1
04/12/2018	08:00	S/D	S/D	S/D	S/D	S/D
04/12/2018	14:00	S/D	S/D	S/D	S/D	S/D
06/12/2018	08:00	S/D	S/D	S/D	S/D	S/D
06/12/2018	11:00	S/D	S/D	S/D	S/D	S/D
06/12/2018	12:00	S/D	0	S/D	98	4.9
07/12/2018	08:00	S/D	S/D	S/D	S/D	S/D
08/12/2018	10:00	S/D	S/D	S/D	S/D	S/D
08/12/2018	11:00	S/D	S/D	S/D	121	5.3
08/12/2018	12:00	S/D	S/D	S/D	S/D	S/D
09/12/2018	08:00	S/D	S/D	S/D	S/D	S/D
10/12/2018	08:00	S/D	S/D	S/D	S/D	S/D
11/12/2018	08:00	S/D	S/D	S/D	S/D	S/D
12/12/2018	08:00	S/D	S/D	S/D	S/D	S/D
13/12/2018	08:00	S/D	S/D	S/D	S/D	S/D
17/12/2018	09:00	S/D	S/D	S/D	S/D	S/D
18/12/2018	11:00	S/D	S/D	S/D	S/D	S/D
18/12/2018	12:00	S/D	S/D	S/D	S/D	S/D
19/12/2018	11:00	S/D	S/D	S/D	S/D	S/D
20/12/2018	08:00	S/D	S/D	S/D	S/D	S/D
20/12/2018	12:00	S/D	S/D	S/D	S/D	S/D
23/12/2018	08:00	S/D	S/D	S/D	S/D	S/D
24/12/2018	11:00	S/D	S/D	S/D	103	2.5
24/12/2018	12:00	S/D	S/D	S/D	119	2.2
24/12/2018	13:00	S/D	0	S/D	92	3.4
24/12/2018	15:00	15.8	S/D	S/D	S/D	S/D
27/12/2018	13:00	S/D	0	S/D	102	3.6
28/12/2018	08:00	S/D	S/D	S/D	S/D	S/D
29/12/2018	12:00	S/D	S/D	S/D	S/D	S/D
30/12/2018	12:00	S/D	0	S/D	89	4.4
30/12/2018	13:00	S/D	S/D	S/D	S/D	S/D

Enero del 2019

Estación : PUNO					
Departamento :	PUNO	Provincia :	PUNO	Distrito :	PUNO
Latitud :	15°49'34.5''	Longitud :	70°0'43.5''	Altitud :	3812 msnm.
Tipo :	EMA - Meteorológica	Código :	472DD33A		

AÑO / MES / DÍA	HORA	TEMPERATURA (°C)	PRECIPITACIÓN (mm/hora)	HUMEDAD (%)	DIRECCION DEL VIENTO (°)	VELOCIDAD DEL VIENTO (m/s)
04/01/2019	11:00	S/D	S/D	S/D	S/D	S/D
04/01/2019	12:00	S/D	S/D	S/D	80	3.4
05/01/2019	12:00	S/D	S/D	S/D	78	3.9
10/01/2019	08:00	S/D	S/D	S/D	S/D	S/D
10/01/2019	14:00	S/D	S/D	S/D	S/D	S/D
13/01/2019	10:00	8.8	0	74	126	1.7
15/01/2019	12:00	9.8	S/D	84	119	2.4
16/01/2019	13:00	S/D	S/D	S/D	S/D	S/D
17/01/2019	12:00	S/D	0	S/D	31	2.6
17/01/2019	13:00	S/D	0	S/D	78	4
17/01/2019	14:00	S/D	0	S/D	117	3.3
17/01/2019	15:00	S/D	0	S/D	117	3.9
19/01/2019	14:00	S/D	S/D	S/D	105	4.4
20/01/2019	10:00	14.3	0	53	103	3.9
21/01/2019	08:00	S/D	0	S/D	99	4.2
22/01/2019	10:00	S/D	0	S/D	90	3.9
22/01/2019	13:00	S/D	S/D	S/D	88	3.8
23/01/2019	09:00	0	S/D	S/D	S/D	S/D
23/01/2019	10:00	S/D	S/D	S/D	S/D	S/D
23/01/2019	11:00	9.9	0.2	76	109	3
23/01/2019	12:00	11.7	S/D	64	105	2.5
23/01/2019	13:00	13.1	0	57	102	2.6
24/01/2019	09:00	S/D	S/D	S/D	S/D	S/D
24/01/2019	10:00	S/D	S/D	S/D	117	1.6
24/01/2019	14:00	S/D	0	S/D	85	5.7
25/01/2019	08:00	S/D	S/D	S/D	83	5.6
25/01/2019	10:00	10.1	0	72	251	1.7
26/01/2019	14:00	15.9	0	42	79	6.2
26/01/2019	15:00	S/D	S/D	S/D	S/D	S/D
27/01/2019	11:00	S/D	S/D	S/D	S/D	S/D
27/01/2019	12:00	S/D	0	S/D	132	2.8
27/01/2019	14:00	13.9	0	53	87	4.8
28/01/2019	08:00	S/D	0	S/D	99	4.5
28/01/2019	12:00	S/D	S/D	S/D	103	3.8
28/01/2019	14:00	S/D	S/D	S/D	S/D	S/D
29/01/2019	10:00	S/D	S/D	S/D	S/D	S/D
29/01/2019	12:00	10.6	0	72	114	2.6
29/01/2019	14:00	13	0	S/D	96	4.6
30/01/2019	09:00	S/D	S/D	S/D	S/D	S/D
30/01/2019	13:00	S/D	0	S/D	77	2.2
30/01/2019	14:00	S/D	0	S/D	129	2.4

Febrero del 2019

Estación : PUNO						
Departamento : PUNO		Provincia : PUNO		Distrito : PUNO		
Latitud : 15°49'34.5''		Longitud : 70°0'43.5''		Altitud : 3812 msnm.		
Tipo : EMA - Meteorológica		Código : 472DD33A				
AÑO / MES / DÍA	HORA	TEMPERATURA (°C)	PRECIPITACIÓN (mm/hora)	HUMEDAD (%)	DIRECCION DEL VIENTO (°)	VELOCIDAD DEL VIENTO (m/s)
01/02/2019	08:00	S/D	0.6	S/D	103	1.5
01/02/2019	09:00	9.8	0	70	302	1.3
01/02/2019	14:00	14.2	0	58	104	4.2
02/02/2019	11:00	S/D	S/D	S/D	116	0.9
02/02/2019	12:00	S/D	0	S/D	250	0.5
02/02/2019	13:00	12.2	0	70	108	3.6
03/02/2019	12:00	S/D	S/D	S/D	106	5.2
04/02/2019	09:00	9.6	0	73	135	1.4
04/02/2019	10:00	S/D	0	S/D	96	4.1
28/02/2019	17:00	13.1	0	59	58	4.4
28/02/2019	18:00	13.4	0	56	70	4.2
28/02/2019	19:00	12.5	0	65	65	3.6
28/02/2019	20:00	11.5	0	72	9	3.5
28/02/2019	21:00	10.8	0	72	199	3.1
28/02/2019	22:00	9.2	0.8	69	321	1
28/02/2019	23:00	8.7	0	75	262	1.3

Marzo del 2019

Estación : PUNO					
Departamento : PUNO		Provincia : PUNO		Distrito : PUNO	
Latitud : 15°49'34.5''		Longitud : 70°0'43.5''		Altitud : 3812 msnm.	
Tipo : EMA - Meteorológica		Código : 472DD33A			

AÑO / MES / DÍA	HORA	TEMPERATURA (°C)	PRECIPITACIÓN (mm/hora)	HUMEDAD (%)	DIRECCION DEL VIENTO (°)	VELOCIDAD DEL VIENTO (m/s)
01/03/2019	00:00	8.2	0	79	297	1.5
01/03/2019	21:00	12.1	0	57	134	3.3
01/03/2019	22:00	11.8	0	57	218	2.4
01/03/2019	23:00	11.4	0	54	173	3.4
02/03/2019	00:00	11.1	0	57	209	2.2
02/03/2019	01:00	10.6	0	61	124	8
02/03/2019	02:00	8.1	0.4	81	218	2.2
24/03/2019	23:00	8	0	73	300	2.8
25/03/2019	12:00	13.1	0	51	25	3
25/03/2019	13:00	14.8	0	43	6	3
25/03/2019	14:00	15.6	0	39	11	2.8
25/03/2019	15:00	16.5	0	37	358	3.5
25/03/2019	16:00	16.4	0	38	74	4.7
25/03/2019	17:00	14.7	0	48	72	5.2
25/03/2019	18:00	13.3	0	51	59	2.9
25/03/2019	19:00	11.4	0.4	66	143	3.7
25/03/2019	20:00	9.6	0	77	184	6.4
25/03/2019	21:00	8.6	0	81	189	3.1
25/03/2019	22:00	9.3	0	69	128	4.8
25/03/2019	23:00	9.3	0	72	198	2.5
26/03/2019	00:00	9.3	0	70	309	0.7
26/03/2019	01:00	9.3	0	66	214	1.4
26/03/2019	02:00	8.8	0	78	65	2
26/03/2019	19:00	11.7	0	66	48	2.8
26/03/2019	20:00	11.5	0	69	49	2.4
26/03/2019	21:00	11.5	0	71	44	2.3
26/03/2019	22:00	11.2	0	75	62	3.2
26/03/2019	23:00	8.4	2.4	83	237	4.4
27/03/2019	00:00	7.5	0	79	222	2.3
27/03/2019	01:00	7.6	0	78	200	3.2
27/03/2019	02:00	7.5	0	77	332	1.1
27/03/2019	03:00	7.5	0	78	292	2.1
28/03/2019	21:00	11.4	0	66	116	4.1
28/03/2019	22:00	10.9	0	68	138	3.5
28/03/2019	23:00	10.4	0	69	129	2.5
29/03/2019	00:00	9	0	78	299	1.2
29/03/2019	01:00	8.4	0	82	316	0.9
29/03/2019	02:00	8.4	0	83	313	0.9
29/03/2019	03:00	9.4	0	74	60	2.1
29/03/2019	04:00	9.5	0	73	44	2.6
29/03/2019	05:00	9.3	0	74	104	4.3
30/03/2019	00:00	9.9	0	73	40	1
30/03/2019	01:00	9.3	0	73	294	1.1
30/03/2019	02:00	9.4	0	75	68	4.1
30/03/2019	03:00	9.8	0	73	35	2.4
31/03/2019	00:00	9.7	0	82	333	1.2
31/03/2019	01:00	8.8	0	86	284	1.6
31/03/2019	02:00	8	0	86	309	1.6
31/03/2019	03:00	7.9	0	87	309	1.1

Mayo del 2019

01/05/2019	00:00	7.9	0	71	309	1.9
01/05/2019	01:00	7.3	0	68	316	1.8
01/05/2019	02:00	6.9	0	45	265	1.9
01/05/2019	03:00	6	0	42	329	1.6
29/05/2019	22:00	9.4	0	25	302	1.7
29/05/2019	23:00	7.8	0	28	308	1.4
30/05/2019	00:00	7	0	30	292	2.1
30/05/2019	01:00	6.3	0	32	311	1.6
30/05/2019	02:00	5.4	0	35	284	2.1
30/05/2019	03:00	5.4	0	33	289	0.9
30/05/2019	04:00	5.4	0	33	261	3.7
30/05/2019	05:00	5.2	0	33	320	1
30/05/2019	06:00	3.8	0	38	345	1.5
30/05/2019	07:00	3	0	43	321	1.2
30/05/2019	08:00	3.1	0	46	314	1
30/05/2019	09:00	7.5	0	37	109	0.9
30/05/2019	10:00	9.2	0	34	120	1.9
30/05/2019	11:00	11	0	38	88	3.6
30/05/2019	12:00	13.1	0	34	101	4.9
30/05/2019	13:00	13.8	0	35	104	4.9
30/05/2019	14:00	15.1	0	30	100	5.1
30/05/2019	15:00	14.9	0	35	82	6.1
30/05/2019	16:00	14.6	0	34	75	5.5
30/05/2019	17:00	14.1	0	35	77	3.5
30/05/2019	18:00	13.1	0	44	80	1.1
30/05/2019	19:00	11.2	0	43	296	2.1
30/05/2019	20:00	10.1	0	39	306	1.4
30/05/2019	21:00	9.7	0	23	263	2.8
30/05/2019	22:00	8.6	0	24	343	2.5
30/05/2019	23:00	7.3	0	27	256	2.4
31/05/2019	00:00	6.7	0	27	319	2
31/05/2019	01:00	5.3	0	30	303	1.3
31/05/2019	02:00	4.3	0	32	292	0.8
31/05/2019	03:00	3.3	0	33	319	1.4
31/05/2019	04:00	2.8	0	36	308	1
31/05/2019	05:00	1.9	0	40	319	1.3
31/05/2019	06:00	1.9	0	39	325	1
31/05/2019	07:00	1.2	0	37	283	1.8
31/05/2019	08:00	1.5	0	40	321	1.1
31/05/2019	09:00	6.6	0	31	84	1.9
31/05/2019	12:00	11.9	0	31	101	4
31/05/2019	13:00	13.9	0	27	64	4
31/05/2019	14:00	15.6	0	20	30	2
31/05/2019	15:00	14.9	0	31	105	5.8
31/05/2019	16:00	15.4	0	27	86	4.7
31/05/2019	17:00	14.8	0	27	85	3.9
31/05/2019	18:00	13.6	0	25	44	2
31/05/2019	19:00	12.3	0	27	52	0.9
31/05/2019	20:00	9.8	0	35	312	1.7
31/05/2019	21:00	8.8	0	37	325	0.6
31/05/2019	22:00	9.5	0	25	143	2.7
31/05/2019	23:00	8.1	0	24	320	1.4

Junio del 2019

Estación : PUNO					
Departamento :	PUNO	Provincia :	PUNO	Distrito :	PUNO
Latitud :	15°49'34.5''	Longitud :	70°0'43.5''	Altitud :	3812 msnm.
Tipo :	EMA - Meteorológica	Código :	472DD33A		

AÑO / MES / DÍA	HORA	TEMPERATURA (°C)	PRECIPITACIÓN (mm/hora)	HUMEDAD (%)	DIRECCION DEL VIENTO (°)	VELOCIDAD DEL VIENTO (m/s)
01/06/2019	00:00	7	0	23	307	1.7
01/06/2019	01:00	6.8	0	22	296	1.5
01/06/2019	02:00	5.2	0	25	291	1.7
01/06/2019	03:00	4.2	0	27	303	1.4
01/06/2019	04:00	4.4	0	25	284	1.6
01/06/2019	05:00	3.7	0	26	295	1.5
01/06/2019	06:00	2.5	0	29	310	1.3
30/06/2019	06:00	3.7	0	72	329	1.2
30/06/2019	07:00	3.2	0	77	289	1.2
30/06/2019	08:00	3.4	0	75	348	0.6
30/06/2019	09:00	7	0	63	73	1.7
30/06/2019	10:00	8.9	0	52	132	1.1
30/06/2019	11:00	10.8	0	47	105	2.3
30/06/2019	12:00	12.1	0	48	108	3.6
30/06/2019	13:00	13.2	0	49	108	4.6
30/06/2019	14:00	13.7	0	46	103	6.3
30/06/2019	15:00	14.5	0	45	106	5.2
30/06/2019	16:00	14.8	0	44	94	4.8
30/06/2019	17:00	14.4	0	36	63	3.7
30/06/2019	18:00	12.3	0	49	50	3.4
30/06/2019	19:00	11.3	0	50	54	2
30/06/2019	20:00	10.1	0	55	352	1.1
30/06/2019	21:00	9.1	0	60	294	1.5
30/06/2019	22:00	8.5	0	69	335	1.5
30/06/2019	23:00	7.9	0	78	320	1.3

Julio del 2019

Estación : PUNO						
Departamento : PUNO		Provincia : PUNO		Distrito : PUNO		
Latitud : 15°49'34.5"		Longitud : 70°0'43.5"		Altitud : 3812 msnm.		
Tipo : EMA - Meteorológica		Código : 472DD33A				
AÑO / MES / DÍA	HORA	TEMPERATURA (°C)	PRECIPITACIÓN (mm/hora)	HUMEDAD (%)	DIRECCION DEL VIENTO (°)	VELOCIDAD DEL VIENTO (m/s)
01/05/2019	00:00	7.9	0	71	309	1.9
01/05/2019	01:00	7.3	0	68	316	1.8
01/05/2019	02:00	6.9	0	45	265	1.9
01/05/2019	03:00	6	0	42	329	1.6
29/05/2019	22:00	9.4	0	25	302	1.7
29/05/2019	23:00	7.8	0	28	308	1.4
30/05/2019	00:00	7	0	30	292	2.1
30/05/2019	01:00	6.3	0	32	311	1.6
30/05/2019	02:00	5.4	0	35	284	2.1
30/05/2019	03:00	5.4	0	33	289	0.9
30/05/2019	04:00	5.4	0	33	261	3.7
30/05/2019	05:00	5.2	0	33	320	1
31/05/2019	00:00	6.7	0	27	319	2
31/05/2019	01:00	5.3	0	30	303	1.3
31/05/2019	02:00	4.3	0	32	292	0.8
31/05/2019	03:00	3.3	0	33	319	1.4
31/05/2019	04:00	2.8	0	36	308	1
31/05/2019	05:00	1.9	0	40	319	1.3
31/05/2019	06:00	1.9	0	39	325	1
31/05/2019	07:00	1.2	0	37	283	1.8
31/05/2019	08:00	1.5	0	40	321	1.1
31/05/2019	09:00	6.6	0	31	84	1.9
31/05/2019	12:00	11.9	0	31	101	4
31/05/2019	13:00	13.9	0	27	64	4
31/05/2019	14:00	15.6	0	20	30	2
31/05/2019	15:00	14.9	0	31	105	5.8
31/05/2019	16:00	15.4	0	27	86	4.7
31/05/2019	17:00	14.8	0	27	85	3.9
31/05/2019	18:00	13.6	0	25	44	2
31/05/2019	19:00	12.3	0	27	52	0.9
31/05/2019	20:00	9.8	0	35	312	1.7
31/05/2019	21:00	8.8	0	37	325	0.6
31/05/2019	22:00	9.5	0	25	143	2.7
31/05/2019	23:00	8.1	0	24	320	1.4

Setiembre del 2019

Estación : PUNO						
Departamento : PUNO		Provincia : PUNO		Distrito : PUNO		
Latitud : 15°49'34.5''		Longitud : 70°0'43.5''		Altitud : 3812 msnm.		
Tipo : EMA - Meteorológica		Código : 472DD33A				
AÑO / MES / DÍA	HORA	TEMPERATURA (°C)	PRECIPITACIÓN (mm/hora)	HUMEDAD (%)	DIRECCION DEL VIENTO (°)	VELOCIDAD DEL VIENTO (m/s)
01/09/2019	00:00	6.9	0	52	306	1.5
01/09/2019	01:00	6.6	0	59	296	1.3
01/09/2019	02:00	5.9	0	64	285	2.1
01/09/2019	03:00	5.9	0	47	304	1.5
01/09/2019	04:00	5	0	50	322	0.8
01/09/2019	05:00	4	0	49	297	1.3
01/09/2019	06:00	3.1	0	48	298	1.2
01/09/2019	07:00	2.8	0	49	288	1.7
01/09/2019	08:00	4	0	45	72	1
01/09/2019	09:00	7.6	0	40	109	1.6
01/09/2019	10:00	9.3	0	39	111	2.7
01/09/2019	11:00	11.7	0	29	119	3.8
01/09/2019	12:00	13.8	0	25	102	5.3
01/09/2019	13:00	15.5	0	18	127	5.1
01/09/2019	14:00	15.7	0	28	100	5.7
01/09/2019	15:00	16.8	0	23	93	5.1
01/09/2019	16:00	16.9	0	25	77	7.1
01/09/2019	17:00	15.5	0	29	83	6.9
01/09/2019	18:00	14.4	0	32	74	4.2
01/09/2019	19:00	11.5	0	32	184	2.8
01/09/2019	20:00	11.5	0	32	184	2.8
01/09/2019	21:00	10.3	0	18	188	3.6
01/09/2019	22:00	9.6	0	19	171	3.4
01/09/2019	23:00	8	0	18	305	1.7
30/09/2019	12:00	16.1	0	23	249	2.9
30/09/2019	13:00	17.1	0	20	108	5.1
30/09/2019	14:00	17.3	0	30	92	5
30/09/2019	15:00	17.8	0	23	90	5.1
30/09/2019	16:00	17.6	0	17	83	4.8
30/09/2019	17:00	17.1	0	14	63	4.3
30/09/2019	18:00	16	0	16	59	4.2
30/09/2019	19:00	12.3	0	43	72	1.3
30/09/2019	20:00	12.3	0	43	72	1.3
30/09/2019	21:00	11.6	0	37	166	3.8
30/09/2019	22:00	10.7	0	41	280	1.4
30/09/2019	23:00	9.8	0	47	52	2

Octubre del 2019

Estación : PUNO					
Departamento :	PUNO	Provincia :	PUNO	Distrito :	PUNO
Latitud :	15°49'34.5''	Longitud :	70°0'43.5''	Altitud :	3812 msnm.
Tipo :	EMA - Meteorológica	Código :	472DD33A		

AÑO / MES / DÍA	HORA	TEMPERATURA (°C)	PRECIPITACIÓN (mm/hora)	HUMEDAD (%)	DIRECCION DEL VIENTO (°)	VELOCIDAD DEL VIENTO (m/s)
01/10/2019	00:00	9.7	0	70	34	2.5
01/10/2019	01:00	8.9	0	71	196	2.4
01/10/2019	02:00	7.5	0	58	196	1.9
01/10/2019	03:00	7.6	0	56	349	0.7
01/10/2019	04:00	7.9	0	56	283	1.7
01/10/2019	05:00	7.4	0	57	243	1.8
01/10/2019	06:00	6.5	0	58	300	1
01/10/2019	07:00	6.2	0	58	289	1.5
01/10/2019	08:00	8.1	0	53	117	1.6
01/10/2019	09:00	10.2	0	49	123	2
01/10/2019	10:00	10.9	0	50	108	2.3
01/10/2019	11:00	12.2	0	44	91	1.5
01/10/2019	12:00	14.6	0	35	50	3
01/10/2019	13:00	15	0	34	86	5.9
01/10/2019	14:00	14.2	0	43	94	5.4
01/10/2019	15:00	14.2	0	39	202	2.4
01/10/2019	16:00	13.7	0	40	14	6.7
01/10/2019	17:00	10.4	0	58	86	3.5
01/10/2019	18:00	10.5	0	62	69	2.5
30/10/2019	15:00	17.9	0	23	118	5.1
30/10/2019	16:00	17.8	0	26	87	7.5
30/10/2019	17:00	17	0	30	76	8
30/10/2019	18:00	15.9	0	35	68	5.9
30/10/2019	19:00	12.3	0	51	62	2.9
30/10/2019	20:00	12.3	0	51	62	2.9
30/10/2019	21:00	12	0	49	51	3.2
30/10/2019	22:00	11.2	0	50	83	1.7
30/10/2019	23:00	10.1	0	58	69	2.7
31/10/2019	00:00	9.8	0	64	61	2.1
31/10/2019	01:00	9.3	0	65	146	3.2
31/10/2019	02:00	9.2	0	68	49	2.5
31/10/2019	03:00	8.5	0	73	50	1.9
31/10/2019	04:00	8.4	0	73	59	2.1
31/10/2019	05:00	8.4	0	71	7	3.3
31/10/2019	06:00	8.3	0	71	355	2.4
31/10/2019	07:00	8.1	0	68	80	1.9
31/10/2019	08:00	9.2	0	65	74	2.4
31/10/2019	09:00	11.2	0	50	67	5.1
31/10/2019	10:00	12.8	0	43	86	4.9
31/10/2019	11:00	13.5	0	38	86	5.1
31/10/2019	12:00	14.5	0	36	93	5.6
31/10/2019	13:00	15.2	0	36	94	6.2
31/10/2019	14:00	15.2	0	40	86	6.7
31/10/2019	15:00	15.1	0	43	77	5.9
31/10/2019	16:00	15.1	0	42	94	7.4
31/10/2019	17:00	14.9	0	41	84	6.8
31/10/2019	18:00	14	0	42	72	6.3
31/10/2019	19:00	11.8	0	53	58	2.3
31/10/2019	20:00	11.8	0	53	58	2.3
31/10/2019	21:00	11.2	0	60	58	1.3
31/10/2019	22:00	11.1	0	59	53	1.5
31/10/2019	23:00	10.6	0	65	72	4

Noviembre del 2019

Estación : PUNO						
Departamento : PUNO		Provincia : PUNO		Distrito : PUNO		
Latitud : 15°49'34.5''		Longitud : 70°0'43.5''		Altitud : 3812 msnm.		
Tipo : EMA - Meteorológica		Código : 472DD33A				
AÑO / MES / DÍA	HORA	TEMPERATURA (°C)	PRECIPITACIÓN (mm/hora)	HUMEDAD (%)	DIRECCION DEL VIENTO (°)	VELOCIDAD DEL VIENTO (m/s)
01/11/2019	00:00	10.2	0	76	63	2.8
01/11/2019	01:00	10	0	78	34	2.2
01/11/2019	02:00	9.6	0	76	36	2.4
01/11/2019	03:00	9.3	0	75	54	1.7
01/11/2019	04:00	9.3	0	73	328	1.6
01/11/2019	05:00	8.7	0	76	29	1
01/11/2019	06:00	8.9	0	73	20	1.3
01/11/2019	07:00	8.6	0	74	357	1.8
01/11/2019	08:00	9	0	68	231	3.8
01/11/2019	09:00	7.5	0	77	201	3.3
01/11/2019	10:00	6.7	0.2	90	212	1.8
30/11/2019	00:00	10.3	0	26	299	1.1
30/11/2019	01:00	9.8	0	27	316	1.3
30/11/2019	02:00	8.9	0	29	298	1
30/11/2019	03:00	7.6	0	33	305	1.2
30/11/2019	04:00	6.9	0	40	297	1
30/11/2019	05:00	6.8	0	42	313	1
30/11/2019	06:00	6.2	0	40	305	1
30/11/2019	07:00	7.5	0	33	259	1.1
30/11/2019	08:00	10.1	0	33	78	1.6
30/11/2019	09:00	12.3	0	26	114	1.5
30/11/2019	10:00	13.5	0	33	106	2.5
30/11/2019	11:00	14.5	0	38	104	3.6
30/11/2019	12:00	15.2	0	41	104	4.3
30/11/2019	13:00	15.4	0	44	103	5
30/11/2019	14:00	16.5	0	42	113	4.4
30/11/2019	15:00	17.3	0	35	82	6.2
30/11/2019	16:00	17.7	0	28	73	6.2
30/11/2019	17:00	16.9	0	37	71	6.7
30/11/2019	18:00	15.2	0	51	72	6.6
30/11/2019	19:00	13.4	0	58	63	2.2
30/11/2019	20:00	13	0	60	156	3.2
30/11/2019	21:00	12.4	0	55	264	2.3
30/11/2019	22:00	11.4	0	51	252	5
30/11/2019	23:00	11.1	0	43	288	2.4

A-5 ASTM C31 FABRICACION DE TESTIGOS DE CONCRETO

"Práctica Estándar Para Fabricación Y Curado De Especímenes De Concreto (ASTM C 31/ C 31M – 03ª

Designation: C 31/C 31M – 03a

Standard Practice for Making and Curing Concrete Test Specimens in the Field[1]

This standard is issued under the fixed designation C 31/C 31M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope

1.1 This practice covers procedures for making and curing cylinder and beam specimens from representative samples of fresh concrete for a construction project.

1.2 The concrete used to make the molded specimens shall be sampled after all on-site adjustments have been made to the mixture proportions, including the addition of mix water and admixtures. This practice is not satisfactory for making specimens from concrete not having measurable slump or requiring other sizes or shapes of specimens.

1.3 The values stated in either inch-pound units or SI units shall be regarded separately as standard. The SI units are shown in brackets. The values stated may not be exact equivalents; therefore each system must be used independently of the other. Combining values from the two units may result in nonconformance.

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

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

2. Referenced Documents

2.1 *ASTM Standards:*

C 125 Terminology Relating to Concrete and Concrete Aggregates[2]

C 138/C 138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete[2]

C 143/C 143M Test Method for Slump of Hydraulic Cement Concrete[2]

C 172 Practice for Sampling Freshly Mixed Concrete[2]

C 173/C 173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method[2]

C 192/C 192M Practice for Making and Curing Concrete Test Specimens in the Laboratory[2]

C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[2]

C 330 Specification for Lightweight Aggregates for Structural Concrete[2]

C 403/C 403M Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance[2]

C 470/C 470M Specification for Molds for Forming Concrete Test Cylinders Vertically[2]

C 511 Specification for Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes[3]

C 617 Practice for Capping Cylindrical Concrete Specimens[2]

C 1064/C 1064M Test Method for Temperature of Freshly Mixed Portland Cement Concrete[2]

2.2 *American Concrete Institute Publication:*[4]

CP-1 Concrete Field Testing Technician, Grade I

309R Guide for Consolidation of Concrete

3. Terminology

3.1 For definitions of terms used in this practice, refer to Terminology C 125.

4. Significance and Use

4.1 This practice provides standardized requirements for making, curing, protecting, and transporting concrete test specimens under field conditions.

4.2 If the specimens are made and standard cured, as stipulated herein, the resulting strength test data when the specimens are tested are able to be used for the following purposes:

4.2.1 Acceptance testing for specified strength,

4.2.2 Checking adequacy of mixture proportions for strength, and

[1] This practice 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. 10, 2003. Published April 2003. Originally approved in 1920. Last previous edition approved in 2003 as C 31/C 31M-03.

[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.01.

[4] Available from American Concrete Institute, P.O. Box 9094, Farmington Hills, MI 48333-9094.

4.2.3 Quality control.

4.3 If the specimens are made and field cured, as stipulated herein, the resulting strength test data when the specimens are tested are able to be used for the following purposes:

4.3.1 Determination of whether a structure is capable of being put in service,

4.3.2 Comparison with test results of standard cured specimens or with test results from various in-place test methods,

4.3.3 Adequacy of curing and protection of concrete in the structure, or

4.3.4 Form or shoring removal time requirements.

5. Apparatus

5.1 *Molds, General*— Molds for specimens or fastenings thereto in contact with the concrete shall be made of steel, cast iron, or other nonabsorbent material, nonreactive with concrete containing portland or other hydraulic cements. Molds shall hold their dimensions and shape under all conditions of use. Molds shall be watertight during use as judged by their ability to hold water poured into them. Provisions for tests of water leakage are given in the Test Methods for Elongation, Absorption, and Water Leakage section of Specification C 470/C 470M. A suitable sealant, such as heavy grease, modeling clay, or microcrystalline wax shall be used where necessary to prevent leakage through the joints. Positive means shall be provided to hold base plates firmly to the molds. Reusable molds shall be lightly coated with mineral oil or a suitable nonreactive form release material before use.

5.2 *Cylinder Molds*— Molds for casting concrete test specimens shall conform to the requirements of Specification C 470/C 470M.

5.3 *Beam Molds*—Beam molds shall be of the shape and dimensions required to produce the specimens stipulated in 6.2. The inside surfaces of the molds shall be smooth. The sides, bottom, and ends shall be at right angles to each other and shall be straight and true and free of warpage. Maximum variation from the nominal cross section shall not exceed ⅛ in. [3 mm] for molds with depth or breadth of 6 in. [150 mm] or more. Molds shall produce specimens at least as long but not more than 1⁄16 in. [2 mm] shorter than the required length in 6.2.

5.4 *Tamping Rod*— A round, straight steel rod with the dimensions conforming to those in Table 1, having the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.

5.5 *Vibrators*—Internal vibrators shall be used. The vibrator frequency shall be at least 7000 vibrations per minute [150 Hz] while the vibrator is operating in the concrete. The diameter of a round vibrator shall be no more than one-fourth the diameter of the cylinder mold or one-fourth the width of the beam mold. Other shaped vibrators shall have a perimeter equivalent to the circumference of an appropriate round vibrator. The combined length of the vibrator shaft and vibrating element shall exceed the depth of the section being vibrated by at least 3 in. [75 mm]. The vibrator frequency shall be checked periodically.

NOTE 1—For information on size and frequency of various vibrators and a method to periodically check vibrator frequency see ACI 309.

TABLE 1 Tamping Rod Requirements

Diameter of Cylinder or Width of Beam in. [mm]	Rod Dimensions[A]	
	Diameter in. [mm]	Length of Rod in. [mm]
<6 [150]	3/8 [10]	12 [300]
6 [150]	5/8 [16]	20 [500]
9 [225]	5/8 [16]	26 [650]

[A] Rod tolerances length ±4 in. [100 mm] and diameter ±1⁄16 in. [2 mm].

5.6 *Mallet*—A mallet with a rubber or rawhide head weighing 1.25 ± 0.50 lb [0.6 ± 0.2 kg] shall be used.

5.7 *Small Tools*— Shovels, hand-held floats, scoops, and a vibrating-reed tachometer shall be provided.

5.8 *Slump Apparatus*— The apparatus for measurement of slump shall conform to the requirements of Test Method C 143/C 143M.

5.9 *Sampling Receptacle*—The receptacle shall be a suitable heavy gage metal pan, wheelbarrow, or flat, clean nonabsorbent board of sufficient capacity to allow easy remixing of the entire sample with a shovel or trowel.

5.10 *Air Content Apparatus*—The apparatus for measuring air content shall conform to the requirements of Test Methods C 173/C 173M or C 231.

5.11 *Temperature Measuring Devices*—The temperature measuring devices shall conform to the applicable requirements of Test Method C 1064/C 1064M.

6. Testing Requirements

6.1 *Cylindrical Specimens*—Compressive or splitting tensile strength specimens shall be cylinders cast and allowed to set in an upright position. The length shall be twice the diameter. The cylinder diameter shall be at least 3 times the nominal maximum size of the coarse aggregate. When the nominal maximum size of the coarse aggregate exceeds 2 in. [50 mm], the concrete sample shall be treated by wet sieving through a 2-in. [50-mm] sieve as described in Practice C 172. For acceptance testing for specified compressive strength, cylinders shall be 6 by 12 in. [150 by 300 mm] or when specified 4 × 8 in. [100 × 200 mm] (Note 2).

NOTE 2—When molds in SI units are required and not available, equivalent inch-pound unit size mold should be permitted.

6.2 *Beam Specimens*— Flexural strength specimens shall be beams of concrete cast and hardened in the horizontal position. The length shall be at least 2 in. [50 mm] greater than three times the depth as tested. The ratio of width to depth as molded shall not exceed 1.5. The standard beam shall be 6 by 6 in. [150 by 150 mm] in cross section, and shall be used for concrete with nominal maximum size coarse aggregate up to 2 in. [50 mm]. When the nominal maximum size of the coarse aggregate exceeds 2 in. [50 mm], the smaller cross sectional dimension of the beam shall be at least three times the nominal maximum size of the coarse aggregate. Unless required by project specifications, beams made in the field shall not have a width or depth of less than 6 in. [150 mm].

6.3 *Field Technicians*—The field technicians making and curing specimens for acceptance testing shall be certified ACI Field Testing Technicians, Grade I or equivalent. Equivalent personnel certification programs shall include both written and performance examinations, as outlined in ACI CP-1.

7. Sampling Concrete

7.1 The samples used to fabricate test specimens under this standard shall be obtained in accordance with Practice C 172 unless an alternative procedure has been approved.

7.2 Record the identification of the sample with respect to the location of the concrete represented and the time of casting.

8. Slump, Air Content, and Temperature

8.1 *Slump*—Measure and record the slump of each batch of concrete from which specimens are made immediately after remixing in the receptacle, as required in Test Method C 143/C 143M.

8.2 *Air Content*— Determine and record the air content in accordance with either Test Method C 173/C 173M or Test Method C 231. The concrete used in performing the air content test shall not be used in fabricating test specimens.

8.3 *Temperature*— Determine and record the temperature in accordance with Test Method C 1064/C 1064M.

NOTE 3—Some specifications may require the measurement of the unit weight of concrete. The volume of concrete produced per batch may be desired on some projects. Also, additional information on the air content measurements may be desired. Test Method C 138/C 138M is used to measure the unit weight, yield, and gravimetric air content of freshly mixed concrete.

9. Molding Specimens

9.1 *Place of Molding*— Mold specimens promptly on a level, rigid surface, free of vibration and other disturbances, at a place as near as practicable to the location where they are to be stored.

9.2 *Casting Cylinders*—Select the proper tamping rod from 5.4 and Table 1 or the proper vibrator from 5.5. Determine the method of consolidation from Table 2, unless another method is specified. If the method of consolidation is rodding, determine molding requirements from Table 3. If the method of consolidation is vibration, determine molding requirements from Table 4. Select a small tool of a size and shape large enough so each amount of concrete obtained from the sampling receptacle will be representative and small enough so concrete is not lost when being placed in the mold. While placing the concrete in the mold, move the small tool around the perimeter of the mold opening to ensure an even distribution of the concrete and minimize segregation. Each layer of concrete shall be consolidated as required. In placing the final layer, add an amount of concrete that will fill the mold after consolidation.

9.3 *Casting Beams*— Select the proper tamping rod from 5.4 and Table 1 or proper vibrator from 5.5. Determine the method of consolidation from Table 2, unless another method is specified. If the method of consolidation is rodding, determine the molding requirements from Table 3. If the method of consolidation is vibration, determine the molding requirements from Table 4. Determine the number of roddings per layer, one for each 2 in.^{2} [14 cm^2] of the top surface area of the beam. Select a small tool, of the size and shape large enough so each amount of concrete obtained from the sampling receptacle is representative and small enough so concrete is not lost when placed in the mold. Each layer shall be consolidated as required. In placing the final layer, add an amount of concrete that will fill the mold after consolidation. Place the concrete so that it is uniformly distributed within each layer with a minimum of segregation.

TABLE 2 Method of Consolidation Requirements

Slump in. (mm)	Method of Consolidation
≥ 1 [25]	rodding or vibration
< 1 [25]	vibration

TABLE 3 Molding Requirements by Rodding

Specimen Type and Size	Number of Layers of Approximately Equal Depth	Number of Roddings per Layer
Cylinders:		
Diameter, in. [mm]		
4 [100]	2	25
6 [150]	3	25
9 [225]	4	50
Beams:		
Width, in. [mm]		
6 [150] to 8 [200]	2	see 9.3
>8 [200]	3 or more equal depths, each not to exceed 6 in. [150 mm].	see 9.3

TABLE 4 Molding Requirements by Vibration

Specimen Type and Size	Number of Layers	Number of Vibrator Insertions per Layer	Approximate Depth of Layer, in. [mm]
Cylinders:			
Diameter, in. [mm]			
4 [100]	2	1	one-half depth of specimen
6 [150]	2	2	one-half depth of specimen
9 [225]	2	4	one-half depth of specimen
Beams:			
Width, in. [mm]			
6 [150] to 8 [200]	1	see 9.4.2	depth of specimen
over 8 [200]	2 or more	see 9.4.2	8 [200] as near as practicable

9.4 *Consolidation*— The methods of consolidation for this practice are rodding or internal vibration.

9.4.1 *Rodding*—Place the concrete in the mold, in the required number of layers of approximately equal volume. Rod each layer with the rounded end of the rod using the required number of roddings. Rod the bottom layer throughout its depth. Distribute the roddings uniformly over the cross section of the mold. For each upper layer, allow the rod to penetrate through the layer being rodded and into the layer below approximately 1 in. [25 mm]. After each layer is rodded, tap the outsides of the mold lightly 10 to 15 times with the mallet, to close any holes left by rodding and to release any large air bubbles that may have been trapped. Use an open hand to tap light-gage single-use cylinder molds which are susceptible to damage if tapped with a mallet. After tapping, spade each layer of the concrete along the sides and ends of beam molds with a trowel or other suitable tool. Underfilled molds shall be adjusted with representative concrete during consolidation of the top layer. Overfilled molds shall have excess concrete removed.

9.4.2 *Vibration*—Maintain a uniform duration of vibration for the particular kind of concrete, vibrator, and specimen mold involved. The duration of vibration required will depend upon the workability of the concrete and the effectiveness of the vibrator. Usually sufficient vibration has been applied as soon as the surface of the concrete has become relatively smooth and large air bubbles cease to break through the top surface. Continue vibration only long enough to achieve proper consolidation of the concrete (see Note 4). Fill the molds and vibrate in the required number of approximately equal layers. Place all the concrete for each layer in the mold before starting vibration of that layer. In compacting the specimen, insert the vibrator slowly and do not allow it to rest on the bottom or sides of the mold. Slowly withdraw the vibrator so that no large air pockets are left in the specimen. When placing the final layer, avoid overfilling by more than ¼ in. [6 mm].

NOTE 4—Generally, no more than 5 s of vibration should be required for each insertion to adequately consolidate concrete with a slump greater than 3 in. [75 mm]. Longer times may be required for lower slump concrete, but the vibration time should rarely have to exceed 10 s per insertion.

9.4.2.1 *Cylinders*—The number of insertions of the vibrator per layer is given in Table 4. When more than one insertion per layer is required distribute the insertion uniformly within each layer. Allow the vibrator to penetrate through the layer being vibrated, and into the layer below, approximately 1 in. [25 mm]. After each layer is vibrated, tap the outsides of the mold at least 10 times with the mallet, to close holes that remain and to release entrapped air voids. Use an open hand to tap cardboard and single-use metal molds that are susceptible to damage if tapped with a mallet.

9.4.2.2 *Beams*—Insert the vibrator at intervals not exceeding 6 in. [150 mm] along the center line of the long dimension of the specimen. For specimens wider than 6 in., use alternating insertions along two lines. Allow the shaft of the vibrator to penetrate into the bottom layer approximately 1 in. (25 mm). After each layer is vibrated, tap the outsides of the mold sharply at least 10 times with the mallet to close holes left by vibrating and to release entrapped air voids.

9.5 *Finishing*—After consolidation, strike off excess concrete from the surface and float or trowel as required. Perform all finishing with the minimum manipulation necessary to produce a flat even surface that is level with the rim or edge of the mold and that has no depressions or projections larger than ⅛ in. [3.3 mm].

9.5.1 *Cylinders*—After consolidation, finish the top surfaces by striking them off with the tamping rod where the consistency of the concrete permits or with a wood float or trowel. If desired, cap the top surface of freshly made cylinders with a thin layer of stiff portland cement paste which is permitted to harden and cure with the specimen. See section on Capping Materials of Practice C 617.

9.5.2 *Beams*—After consolidation of the concrete, use a hand-held float to strike off the top surface to the required tolerance to produce a flat, even surface.

9.6 *Identification*— Mark the specimens to positively identify them and the concrete they represent. Use a method that will not alter the top surface of the concrete. Do not mark the removable caps. Upon removal of the molds, mark the test specimens to retain their identities.

10. Curing

10.1 *Standard Curing*— Standard curing is the curing method used when the specimens are made and cured for the purposes stated in 4.2.

10.1.1 *Storage*—If specimens cannot be molded at the place where they will receive initial curing, immediately after finishing move the specimens to an initial curing place for storage. The supporting surface on which specimens are stored shall be level to within ¼ in. per ft [20 mm per m]. If cylinders in the single use molds are moved, lift and support the cylinders from the bottom of the molds with a large trowel or similar device. If the top surface is marred during movement to place of initial storage, immediately refinish.

10.1.2 *Initial Curing*— Immediately after molding and finishing, the specimens shall be stored for a period up to 48 h in a temperature range from 60 and 80°F [16 and 27°C] and in an environment preventing moisture loss from the specimens. For concrete mixtures with a specified strength of 6000 psi [40 MPa] or greater, the initial curing temperature shall be between 68 and 78°F [20 and 26°C]. Various procedures are capable of being used during the initial curing period to maintain the specified moisture and temperature conditions. An appropriate procedure or combination of procedures shall be used (Note 5). Shield all specimens from the direct sunlight and, if used, radiant heating devices. The storage temperature shall be controlled by use of heating and cooling devices, as necessary. Record the temperature using a maximum-minimum thermometer. If cardboard molds are used, protect the outside surface of the molds from contact with wet burlap or other sources of water.

NOTE 5—A satisfactory moisture environment can be created during the initial curing of the specimens by one or more of the following procedures: (1) immediately immerse molded specimens with plastic lids in water saturated with calcium hydroxide, (2) store in properly constructed wooden boxes or structures, (3) place in damp sand pits, (4) cover with removable plastic lids, (5) place inside plastic bags, or (6) cover with plastic sheets or nonabsorbent plates if provisions are made to avoid drying and damp burlap is used inside the enclosure, but the burlap is prevented from contacting the concrete surfaces. A satisfactory temperature environment can be controlled during the initial curing of the specimens by one or more of the following procedures: (1) use of ventilation, (2) use of ice, (3) use of thermostatically controlled heating or cooling devices, or (4) use of heating methods such as stoves or light bulbs. Other suitable methods may be used provided the requirements limiting specimen storage temperature and moisture loss are met. For concrete mixtures with a specified strength of 6000 psi [40 MPa] or greater, heat generated during the early ages may raise the temperature above the required storage temperature. Immersion in water saturated with calcium hydroxide may be the easiest method to maintain the required storage temperature. When specimens are to be immersed in water saturated with calcium hydroxide, specimens in cardboard molds or other molds that expand when immersed in water should not be used. Early-age strength test results may be lower when stored at 60°F [16°C] and higher when stored at 80°F [27°C]. On the other hand, at later ages, test results may be lower for higher initial storage temperatures.

10.1.3 *Final Curing:*

10.1.3.1 *Cylinders*—Upon completion of initial curing and within 30 min after removing the molds, cure specimens with free water maintained on their surfaces at all times at a temperature of 73 ± 3°F [23 ± 2°C] using water storage tanks or moist rooms complying with the requirements of Specification C 511, except when capping with sulfur mortar capping compound and immediately prior to testing. When capping with sulfur mortar capping compound, the ends of the cylinder shall be dry enough to preclude the formation of steam or foam pockets under or in cap larger than ¼ in. [6 mm] as described in Practice C 617. For a period not to exceed 3 h immediately prior to test, standard curing temperature is not required provided free moisture is maintained on the cylinders and ambient temperature is between 68 and 86°F [20 and 30°C].

10.1.3.2 *Beams*—Beams are to be cured the same as cylinders (see 10.1.3.1) except that they shall be stored in water saturated with calcium hydroxide at 73 ± 3°F [23 ± 2°C] at least 20 h prior to testing. Drying of the surfaces of the beam shall be prevented between removal from water storage and completion of testing.

NOTE 6—Relatively small amounts of surface drying of flexural specimens can induce tensile stresses in the extreme fibers that will markedly reduce the indicated flexural strength.

10.2 *Field Curing*— Field curing is the curing method used for the specimens made and cured as stated in 4.3.

10.2.1 *Cylinders*—Store cylinders in or on the structure as near to the point of deposit of the concrete represented as possible. Protect all surfaces of the cylinders from the elements in as near as possible the same way as the formed work. Provide the cylinders with the same temperature and moisture environment as the structural work. Test the specimens in the moisture condition resulting from the specified curing treatment. To meet these conditions, specimens made for the purpose of determining when a structure is capable of being put in service shall be removed from the molds at the time of removal of form work.

10.2.2 *Beams*—As nearly as practicable, cure beams in the same manner as the concrete in the structure. At the end of 48 ± 4 h after molding, take the molded specimens to the storage location and remove from the molds. Store specimens representing pavements of slabs on grade by placing them on the ground as molded, with their top surfaces up. Bank the sides and ends of the specimens with earth or sand that shall be kept damp, leaving the top surfaces exposed to the specified curing treatment. Store specimens representing structure concrete as near the point in the structure they represent as possible, and afford them the same temperature protection and moisture environment as the structure. At the end of the curing period leave the specimens in place exposed to the weather in the same manner as the structure. Remove all beam specimens from field storage and store in water saturated with calcium hydroxide at 73 ± 3°F [23 ± 2°C] for 24 ± 4 h immediately before time of testing to ensure uniform moisture condition from specimen to specimen. Observe the precautions given in 10.1.3.2 to guard against drying between time of removal from curing to testing.

10.3 *Structural Lightweight Concrete Curing*—Cure structural lightweight concrete cylinders in accordance with Specification C 330.

11. Transportation of Specimens to Laboratory

11.1 Prior to transporting, cure and protect specimens as required in Section 10. Specimens shall not be transported until at least 8 h after final set. (See Note 7). During transporting, protect the specimens with suitable cushioning material to prevent damage from jarring. During cold weather, protect the specimens from freezing with suitable insulation material. Prevent moisture loss during transportation by wrapping the specimens in plastic, wet burlap, by surrounding them with wet sand, or tight fitting plastic caps on plastic molds. Transportation time shall not exceed 4 h.

NOTE 7—Setting time may be measured by Test Method C 403.

12. Report

12.1 Report the following information to the laboratory that will test the specimens:

12.1.1 Identification number,

12.1.2 Location of concrete represented by the samples,

12.1.3 Date, time and name of individual molding specimens,

12.1.4 Slump, air content, and concrete temperature, test results and results of any other tests on the fresh concrete and any deviations from referenced standard test methods, and

12.1.5 Curing method. For standard curing method, report the initial curing method with maximum and minimum temperatures and final curing method. For field curing method, report the location where stored, manner of protection from the elements, temperature and moisture environment, and time of removal from molds.

13. Keywords

13.1 beams; casting samples; concrete; curing; cylinders; testing

A-6: MÉTODO DE PRUEBA ESTÁNDAR PARA RESISTENCIA A LA COMPRESIÓN DE LOS ESPECÍMENES CILÍNDRICOS DE CONCRETO (ASTM C39/C39M – 14).

INTERNATIONAL

Designation: C39/C39M – 14

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 and health practices and determine the applicability of regulatory limitations prior to use.* (**Warning**—Means should be provided to contain concrete fragments during sudden rupture of specimens. Tendency for sudden rupture increases with increasing concrete strength and it is more likely when the testing machine is relatively flexible. The safety precautions given in the Manual of Aggregate and Concrete Testing are recommended.)

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C42/C42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C617 Practice for Capping Cylindrical Concrete Specimens

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

C873 Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds

C1077 Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation

C1231/C1231M Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders

E4 Practices for Force Verification of Testing Machines

E74 Practice of Calibration of Force-Measuring Instruments for Verifying the Force Indication of Testing Machines

Manual of Aggregate and Concrete Testing

3. Summary of Test Method

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

4. Significance and Use

4.1 Care must be exercised in the interpretation of the significance of compressive strength determinations by this test method since strength is not a fundamental or intrinsic property of concrete made from given materials. Values obtained will depend on the size and shape of the specimen, batching, mixing procedures, the methods of sampling, molding, and fabrication and the age, temperature, and moisture conditions during curing.

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

4.3 The results of this test method are used as a basis for quality control of concrete proportioning, mixing, and placing

[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, 2014. Published February 2014. Originally approved in 1921. Last previous edition approved in 2012 as C39/C39M–12a. DOI: 10.1520/C0039_C0039M-14.

[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 operations; determination of compliance with specifications; control for evaluating effectiveness of admixtures; and similar uses.

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

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

5. Apparatus

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

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

5.1.1.1 Within 13 months of the last calibration,

5.1.1.2 On original installation or immediately after relocation,

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

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

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

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

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

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

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

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

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

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

$$E = A - B \quad (1)$$

$$E_p = 100(A - B)/B$$

where:

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

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

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

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

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

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

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

5.2.1 Bottom bearing blocks shall conform to the following requirements:

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

greater than the diameter of the specimen to be tested. Concentric circles as described in 5.2 are optional on the bottom block.

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

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

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

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

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

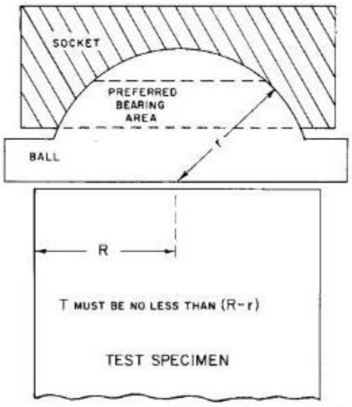
Diameter of Test Specimens, mm [in.]	Maximum Diameter of Bearing Face, mm [in.]
50 [2]	105 [4]
75 [3]	130 [5]
100 [4]	165 [6.5]
150 [6]	255 [10]
200 [8]	280 [11]

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

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

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

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



NOTE 1—Provision shall be made for holding the ball in the socket and for holding the entire unit in the testing machine.

FIG. 1 Schematic Sketch of a Typical Spherical Bearing Block

5.2.2.4 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 machine. The lubricant shall be a petroleum-type oil such as conventional motor oil or as specified by the manufacturer of the testing machine.

NOTE 7—To ensure uniform seating, the spherically seated head 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. Petroleum-type oil such as conventional motor oil has been shown to permit the necessary friction to develop. 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.

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

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

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

5.3 *Load Indication:*

5.3.1 If the load of a compression machine used in concrete testing is registered on a dial, the dial shall be provided with a graduated scale that is readable to at least the nearest 0.1 % of the full scale load (Note 8). The dial shall be readable within 1 % of the indicated load at any given load level within the loading range. In no case shall the loading range of a dial be considered to include loads below the value that is 100 times the smallest change of load that can be read on the scale. The scale shall be provided with a graduation line equal to zero and so numbered. The dial pointer shall be of sufficient length to reach the graduation marks; the width of the end of the pointer shall not exceed the clear distance between the smallest graduations. Each dial shall be equipped with a zero adjustment located outside the dialcase and easily accessible from the front of the machine while observing the zero mark and dial pointer. Each dial shall be equipped with a suitable device that at all times, until reset, will indicate to within 1 % accuracy the maximum load applied to the specimen.

NOTE 8—Readability is considered to be 0.5 mm [0.02 in.] along the arc described by the end of the pointer. Also, one half of a scale interval is readable with reasonable certainty when the spacing on the load indicating mechanism is between 1 mm [0.04 in.] and 2 mm [0.06 in.]. When the spacing is between 2 and 3 mm [0.06 and 0.12 in.], one third of a scale interval is readable with reasonable certainty. When the spacing is 3 mm [0.12 in.] or more, one fourth of a scale interval is readable with reasonable certainty.

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

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

5.4 Documentation of the calibration and maintenance of the testing machine shall be in accordance with Practice C1077.

6. Specimens

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

NOTE 9—This may occur when single use molds are damaged or deformed during shipment, when flexible single use molds are deformed during molding, or when a core drill deflects or shifts during drilling.

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

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

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

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

7. Procedure

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

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

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

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

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

7.4.1 *Zero Verification and Block Seating*—Prior to testing the specimen, verify that the load indicator is set to zero. In cases where the indicator is not properly set to zero, adjust the indicator (Note 10). 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 10—The technique used to verify and adjust load indicator to zero will vary depending on the machine manufacturer. Consult your owner's manual or compression machine calibrator for the proper technique.

7.4.2 *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 11) 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 11—An angle of 0.5° is equal to a slope of approximately 1 mm in 100 mm [⅛ inches in 12 inches]

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

7.5.1 The load shall be applied at a rate of movement (platen to crosshead measurement) corresponding to a stress rate on the specimen of 0.25 ± 0.05 MPa/s [35 ± 7 psi/s] (See Note 12). The designated rate of movement shall be maintained at least during the latter half of the anticipated loading phase.

NOTE 12—For a screw-driven or displacement-controlled testing machine, preliminary testing will be necessary to establish the required rate of movement to achieve the specified stress rate. The required rate of movement will depend on the size of the test specimen, the elastic modulus of the concrete, and the stiffness of the testing machine.

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

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

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

8. Calculation

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

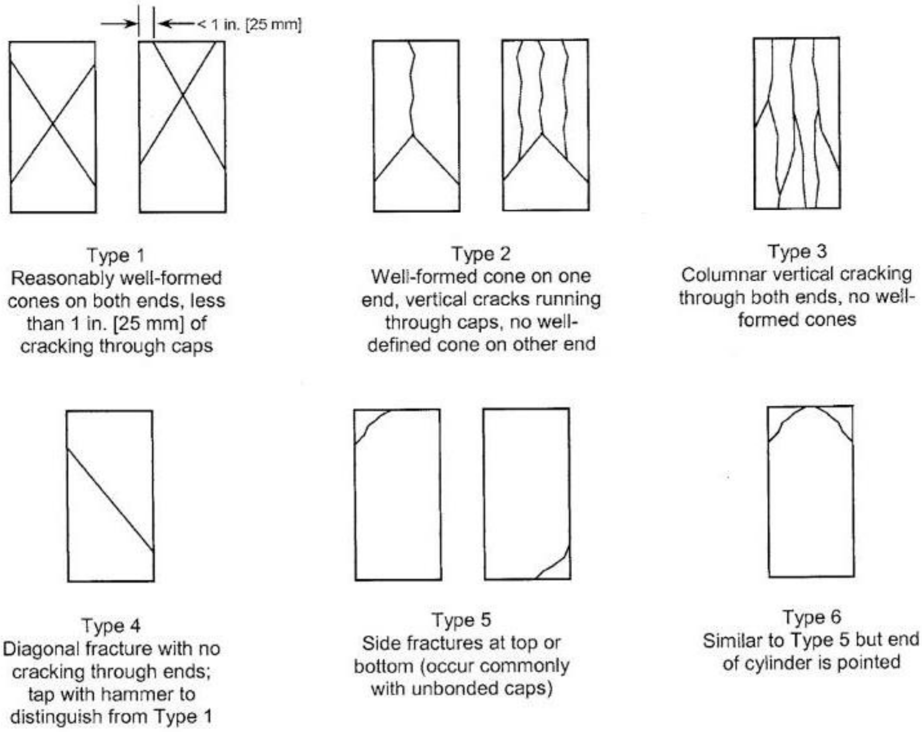


FIG. 2 Schematic of Typical Fracture Patterns

8.2 If the specimen length to diameter ratio is 1.75 or less, correct the result obtained in 8.1 by multiplying by the appropriate correction factor shown in the following table Note 13:

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 13—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].

8.3 When required, calculate the density of the specimen to the nearest 10 kg/m^3 [1 lb/ft^3] as follows:

$$Density = \frac{W}{V} \tag{2}$$

where:

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

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

$$V = \frac{W - W_s}{\gamma_w} \tag{3}$$

where:

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

9. Report

9.1 Report the following information:

9.1.1 Identification number,

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

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

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

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

9.1.6 Type of fracture (see Fig. 2),

9.1.7 Defects in either specimen or caps, and,

9.1.8 Age of specimen.

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

10. Precision and Bias

10.1 *Precision*

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

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

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

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

NOTE 14—The multilaboratory precision does not include variations associated with different operators preparing test specimens from split or independent samples of concrete. These variations are expected to increase the multilaboratory coefficient of variation.

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

NOTE 15—Subcommittee C09.61 will continue to examine recent concrete proficiency sample data and field test data and make revisions to precisions statements when data indicate that they can be extended to cover a wider range of strengths and specimen sizes.

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

[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.

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

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

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this test method since the last issue, C39/C39M–12a, that may impact the use of this test method. (Approved February 1, 2014)

(*1*) Modified 7.4.

(*2*) Added 7.4.2 and Note 11.

Committee C09 has identified the location of selected changes to this test method since the last issue, C39/C39M–12, that may impact the use of this test method. (Approved September 1, 2012)

(*1*) Revised 5.1.1.1.