JDM INGENIERIA SAS

Bogotá D.C., 19 de Enero de 2012

LAB-0001-2012

Señores
CENTRASA S.A.
Atención: Ing. Angela Medina
Carrera 12 No. 72 - 69
Bogotá D.C.

PROYECTO:
FIRMA:
FECHA: 20 ENE 12
RECIBIDO PARA VERIFICACION NO IMPLICA ACEPTACION

11:40 0105

Asunto: Entrega de informe de laboratorio.

Cordial saludo

Mediante el presente comunicado se hace entrega del Informe relacionado a continuación:

- INFORME DE LABORATORIO LAB-116-2011_ VERSIÓN 0_CARACTERIZACIÓN DE MEZCLAS ASFÁLTICAS_MODULOS DINÁMICOS_MEZCLAS TIPO: MDC – 1, MDC – 2, MDC – 12 Y MD – 20_1 TOMO.

Cordialmente,

ING. JOSE DAVID MUÑOZ GUTIERREZ
Gerente Técnico

Copia:	- Archivo
Anexo:	1 Tomos.

Elaboró: MJGO
Revisó: JDMG

CARACTERIZACIÓN DE MEZCLAS ASFÁLTICAS
MÓDULOS DINÁMICOS
MEZCLAS TIPO: MDC-1, MDC-2, MD-12, MD-20




INFORME DE LABORATORIO
LAB-116-2011

VERSIÓN 0

ADMINISTRADORA
DE PROYECTOS CIVILES SAS

INGENIERIA SAS




CERTIFIED IQNet MANAGEMENT SYSTEM

CENTRASA S.A.

ICONTEC
CERTIFICADO
ISO 9001
Certificado N°
SC 1693 - 1

BOGOTÁ D.C., ENERO DE 2012

LISTA DE DISTRIBUCIÓN

El original y las copias del presente estudio han sido entregados a las siguientes dependencias:

DEPENDENCIA	ORIGINAL	COPIA
CENTRASA S.A.	X	

Firma		
Cargo	Director técnico Laboratorio	Gerente
NOMBRE	ING. JAVIER A. ORTIZ M.	Ing. José David Muñoz Gutiérrez
Mat. Profesional	25202-45224CND	25202-50502
0 Rev 11 - 01 - 2012 Fecha	ELABORÓ	REVISÓ

CONTROL DE REVISIONES Y MODIFICACIONES

ESTADO DE REVISIÓN Y APROBACIÓN	NOMBRE	CARGO	FIRMA	FECHA
APROBÓ	Ing. José David Muñoz Gutiérrez	Gerente		Enero de 2012
ELABORÓ	Ing. Javier A. Ortiz M	Director Técnico Laboratorio		Enero de 2012

MODIFICACIONES		
FECHA	VERSIÓN	DESCRIPCIÓN DE LA MODIFICACIÓN
11/01/2012	0	Informe de caracterización dinámica de mezclas Asfálticas tipo MDC-1, MDC-2,(INVIAS) MD-12 Y MD-20 (IDU)

CONTENIDO

Anexos:

- Resultados caracterización Módulo Dinámico de las Mezclas Asfálticas tipo MDC-1, MDC-2,(INVIAS) MD-12 Y MD-20 (IDU)
- Reportes de laboratorio para las Mezclas Asfálticas tipo Rodadura Asfáltica MDC-1 , MDC-2,(INVIAS) MD-12 Y MD20 (IDU)
- Resultados de densidades realizadas a las muestras de las Mezclas Asfálticas tipo MDC-1, MDC-2,(INVIAS) MD-12 Y MD-20 (IDU)
- Registro Fotográfico
- Notas técnicas
- Norma técnica Métodos de ensayo para mezclas bituminosas en caliente. Parte 26: Rigidez (UNE-EN 12697-26, Anexo c)

1. GENERALIDADES

El presente informe contiene los resultados de las pruebas de laboratorio tendientes a caracterizar el comportamiento dinámico de las mezclas asfálticas suministradas por el cliente.

Información básica

Cliente:	CENTRASA S.A.
Tipo de mezcla:	MDC-1, MDC-2, MD-12 Y MD-20
Tipo de muestras:	Marshall
Método de compactación	Impacto
Fecha elaboración de las probetas:	No reporta

La información referente a las probetas y tipo de mezcla fue suministrada por el contratante y corresponden a las muestras de mezcla asfáltica proveniente de planta, elaboradas con mezclas asfálticas, de acuerdo a remisión PCEN-CO-357-2011

Código interno

Las muestras recibidas fueron identificadas con el código interno	**LAB 116**

Fechas de ensayo

En el respectivo reporte de laboratorio se encuentra consignada la información referente a la fecha de ensayo de cada probeta.

Condiciones de almacenamiento

Las probetas fueron almacenadas en condiciones ambiente, con temperaturas entre 15 y 25 °C.

2. NORMAS DE ENSAYO

Para la caracterización de las mezclas el cliente solicita un plan de ensayos consistente en las siguientes pruebas (Tabla 1):

Gravedad específica bulk y densidad de mezclas asfálticas compactadas no absorbentes empleando especímenes saturados y con superficie seca	INV E 733
Métodos de ensayo para mezclas bituminosas en caliente. Parte 26 : Rigidez	UNE-EN 12697-26 Anexo c

Tabla 1. Pruebas de Laboratorio

- **Gravedad específica bulk y densidad de mezclas asfálticas compactadas no absorbentes empleando especímenes saturados y con superficie seca INV E 733**

Este método se refiere a la determinación de la gravedad específica bulk y densidad de especímenes de mezclas asfálticas compactadas.

Gravedad específica bulk – Es la relación entre la masa (peso en el aire) de un volumen dado de material a una determinada temperatura, generalmente a 25°C para mezclas asfálticas, y la masa de un volumen igual de agua destilada, libre de gas, a la misma temperatura.

Densidad bulk – Es la masa del material por metro cúbico (o pie cúbico) del material a 25°C (77°F) para mezclas asfálticas.

El comportamiento a corto y largo plazo de la mezcla está asociado de manera significativa a los niveles de densidad obtenidos en los procesos de fabricación y construcción de la carpeta asfáltica, de ahí la importancia de verificar este parámetro.

3. RESULTADOS

- **Métodos de ensayo para mezclas bituminosas en caliente. Parte 26 : Rigidez (UNE-EN 12697-26, Anexo c)**

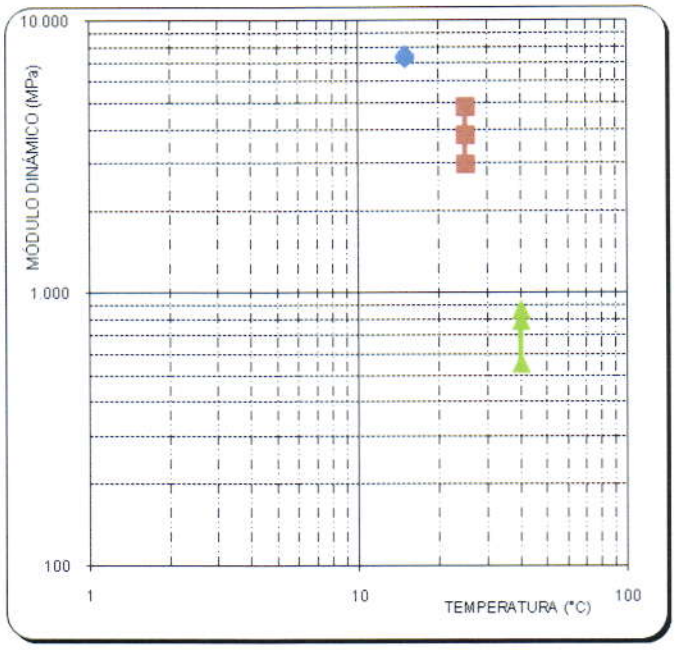
Se evalúa el comportamiento de la mezcla bajo la acción de las cargas dinámicas de acuerdo a los requerimientos del cliente y conforme a lo expresado en la norma UNE-en 12697-26 anexo C, se aplica la carga que aumenta de cero hasta el valor máximo en un tiempo de (124 ±4) ms. Es decir para estos resultados de utilizó una frecuencia de 2.5 Hz, en cumplimiento de la norma citada. La cual se puede emplear de acuerdo al numeral 450.4.2.3 del artículo 450 de las especificaciones de Instituto Nacional de Vías (Invias), que permite la utilización de los procedimientos de la norma internacional para la realización de este ensayo.

En el formato ASF-02 Ensayo de módulo de rigidez dinámico mezcla asfáltica se presentan los resultados, cuyo resumen se presenta en las Gráfica 1 y Tabla 2 para la probeta No. 5 de la mezcla asfáltica MDC-1, la Gráfica 2 y Tabla 3 para la probeta No. 10 de la mezcla asfáltica MDC-2, la Gráfica 3 y Tabla 4 para la probeta No. 6 de la mezcla asfáltica MD-12 y en la Gráfica 4 y Tabla 5 para la probeta No. 3 de MD-20

ENSAYO DE MÓDULO DE RIGIDEZ DINÁMICO - MEZCLA ASFÁLTICA

BRIQUETA	TEMP. (°C)	FREC. (Hz)	Módulo Promedio (MPa)	Densidad (kg/m3)
5	15,00	10,00	7.498	2.198
5	15,00	5,00	7.275	
5	15,00	2,50	7.310	
3	25,00	10,00	4.870	2.207
3	25,00	5,00	3.836	
3	25,00	2,50	2.994	
5	40,00	10,00	874	2.198
5	40,00	5,00	799	
5	40,00	2,50	555	

Tabla 2. Resultados prueba de Módulo Resiliente mezcla tipo MDC-1 (INVIAS)

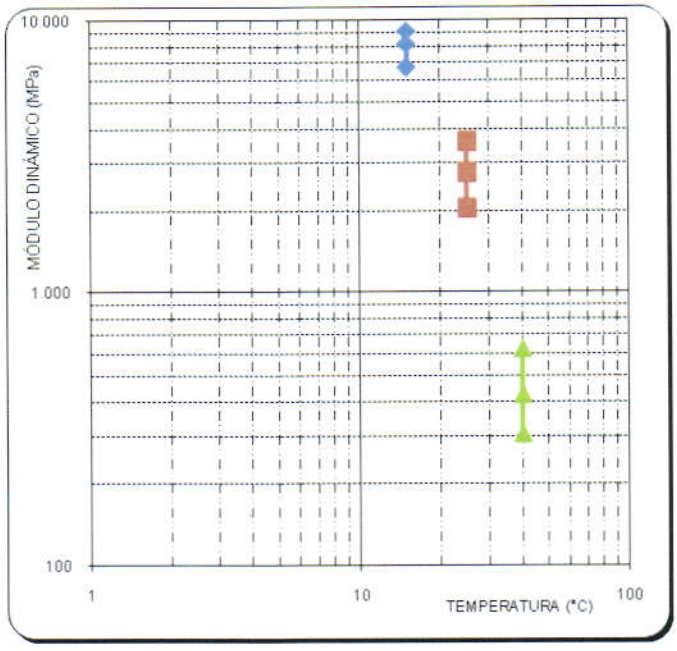


Grafica No. 1. Módulo resiliente en función de la frecuencia y la temperatura correspondiente a la mezcla tipo MDC-1

ENSAYO DE MÓDULO DE RIGIDEZ DINÁMICO - MEZCLA ASFÁLTICA

BRIQUETA	TEMP. (°C)	FREC. (Hz)	Módulo Promedio (MPa)	Densidad (kg/m3)
10	15,00	10,00	9.138	2.134
10	15,00	5,00	8.208	
10	15,00	2,50	6.718	
10	25,00	10,00	3.586	2.134
10	25,00	5,00	2.758	
10	25,00	2,50	2.038	
10	40,00	10,00	628	2.134
10	40,00	5,00	429	
10	40,00	2,50	307	

Tabla 3. Resultados prueba de Módulo Resiliente mezcla tipo MDC-2 (INVIAS)

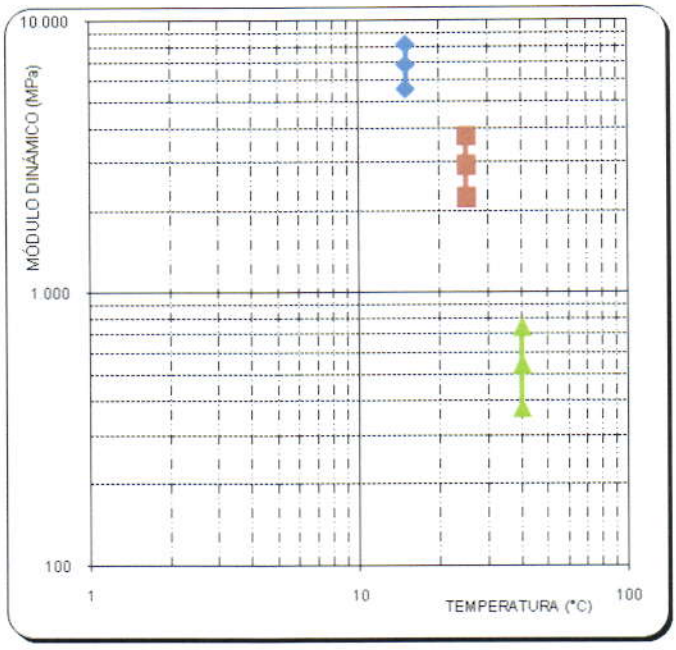


Grafica No. 2. Módulo resiliente en función de la frecuencia y la temperatura correspondiente a la mezcla tipo MDC-2

ENSAYO DE MÓDULO DE RIGIDEZ DINÁMICO - MEZCLA ASFÁLTICA

BRIQUETA	TEMP. (°C)	FREC. (Hz)	Módulo Promedio (MPa)	Densidad (kg/m3)
6	15,00	10,00	8.199	2.246
6	15,00	5,00	6.901	
6	15,00	2,50	5.579	
6	25,00	10,00	3.769	2.246
6	25,00	5,00	2.917	
6	25,00	2,50	2.219	
6	40,00	10,00	746	2.246
6	40,00	5,00	542	
6	40,00	2,50	379	

Tabla 4. Resultados prueba de Módulo Resiliente mezcla tipo MD-12 (IDU)

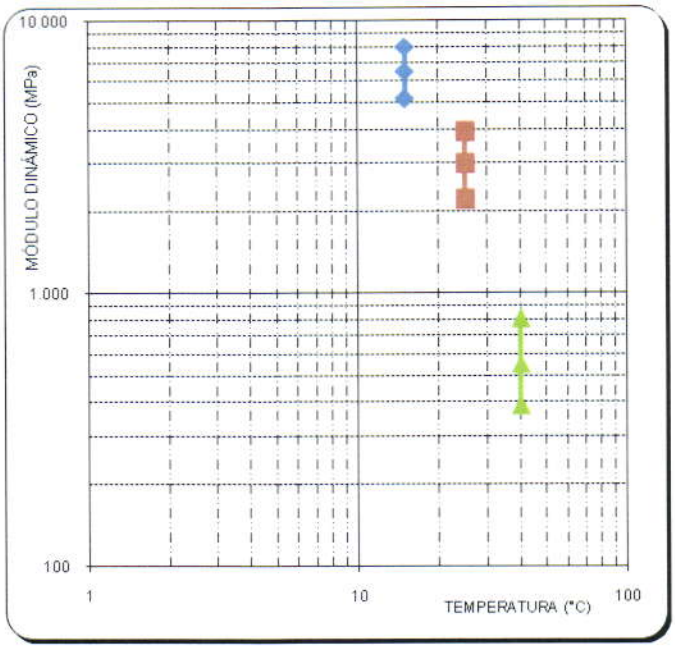


Grafica No. 3. Módulo resiliente en función de la frecuencia y la temperatura correspondiente a la mezcla tipo MD-12

ENSAYO DE MÓDULO DE RIGIDEZ DINÁMICO - MEZCLA ASFÁLTICA

BRIQUETA	TEMP. (°C)	FREC. (Hz)	Módulo Promedio (MPa)	Densidad (kg/m3)
3	15,00	10,00	8.011	2,099
3	15,00	5,00	6.546	
3	15,00	2,50	5.190	
3	25,00	10,00	3.901	2,099
3	25,00	5,00	2.972	
3	25,00	2,50	2.206	
3	40,00	10,00	813	2,099
3	40,00	5,00	554	
3	40,00	2,50	389	

Tabla 5. Resultados prueba de Módulo Resiliente mezcla tipo MD-20 (IDU)



Grafica No. 4. Módulo resiliente en función de la frecuencia y la temperatura correspondiente a la mezcla tipo MD-20

La deducción de la curva maestra se presenta en el formato ASF-03, y ambos formatos forman parte del anexo 1. Se anexan los reportes de cada uno de los ensayos. Para el uso de la curva maestra, se deberá determinar el parámetro de reducción de la curva maestra (X) en función de la frecuencia requerida (f), temperatura requerida (T) y la temperatura de referencia (Ts) presentada en el formato, de acuerdo a las siguientes expresiones:

$$X = \alpha_T + Ln(f)$$

$$\alpha_T = 2{,}52 \cdot 10^4 \cdot \left(\frac{1}{T} - \frac{1}{T_s} \right)$$

X = Parámetro de reducción de la Curva Maestra.

α_T = factor de modificación en función de la temperatura.

f = frecuencia de la prueba en Hz.

T= Temperatura absoluta de la prueba (T=T°C+273,15).

Ts= Temperatura absoluta de referencia (Ts=Ts°C+273,15).

Por ejemplo, para las siguientes condiciones:

Por ejemplo:

f:	2,5	Hz	Requerida de las condiciones del proyecto
T:	21	°C	Requerida de las condiciones del proyecto
Ts:	25	°C	Del reporte de ensayo - Curva maestra
T:	294,15	°K	
Ts:	298,15	°K	
α_T	1,16		
X:	2,07		
Módulo (gráfica):	3391,65	MPa	Curva probeta 6 MD-12

$$X = \alpha_T + Ln(f)$$

$$\alpha_T = 2{,}52 \cdot 10^4 \cdot \left(\frac{1}{T} - \frac{1}{T_s} \right)$$

El valor de X deberá ser usado para la estimación del módulo en la curva maestra.

En los Anexos se encuentran los formatos con las condiciones de ensayo y los resultados de laboratorio.

4. OBSERVACIONES

Los resultados presentados se encuentran dentro de los parámetros de aceptación del método de ensayo en cuanto a la variación de resultados entre los diámetros perpendiculares.

5. NOTAS

Las muestras y su información fueron suministradas por el cliente.

Los resultados, conclusiones y recomendaciones corresponden a las muestras analizadas.

No se deberá reproducir de manera parcial o total los resultados de este informe sin autorización de APC SAS.

FIRMA _____

Director Técnico de Laboratorio (APC SAS)

RECIBIDO POR: _____

6. REFERENCIAS

AENOR. EN12697-26 Mezclas Bituminosas. Métodos de ensayo para mezcla bituminosa en caliente. Parte 26. Rigidez. 2006.

Ahmed Samy Noereldin (1995), Development of temperature coefficient for the AASHTO flexible pavement design equation, Proc. Second Int. Conf. on Road and Airfield Pavement Technology, Vol. 1, pp. 221-235, Singapore.

Cooper, 2010. Documento de referencia "NOTES ON METHODS OF MEASURING STIFFNESS ACCORDING TO THE BS DD 213 METHOD AND THE ATSM METHOD".

GILLESPIE T.D., KARAMIHAS S.M., SAYERS M.W., NASIM M.A., HANSEN W., and EHSAN N., "Effects of Heavy-Vehicle Characteristics on Pavement Response and Performance", Transportation Research Board, National Research Council, Report No. 353, National Academy Press, Washington D. C., 1993, pp. 24-34.

HUANG, YANG H. (2004) Pavement analysis and design. Second Edition, Prentice Hall. Upper Saddle River, NJ. USA.

ANEXO 1.
RESULTADOS CARACTERIZACIÓN MÓDULO DINÁMICO DE LAS MEZCLAS ASFÁLTICAS TIPO MDC-1, MDC-2, MD-12 Y MD-20

ADMINISTRADORA DE PROYECTOS CIVILES SAS
Calle 154 No. 17-78 Bogotá, D.C.
teléfonos 527 0376 - 626 1884
laboratorio@apcltda.net
direcciontecnica@apcltda.net

Formato ASF-02

ENSAYO DE MÓDULO DE RIGIDEZ DINÁMICO - MEZCLA ASFÁLTICA

INSTRUCTIVO:IE-AF2-01 PROCEDIMIENTO DE ENSAYO: EN 12697:2004 ANEXO C

CÓDIGO ORDEN: 116 **PROYECTO:** MODULOS CENTRASA

Tipo de mezcla: MDC-1 - INVIAS **Fecha Recepción:** 14-dic-11

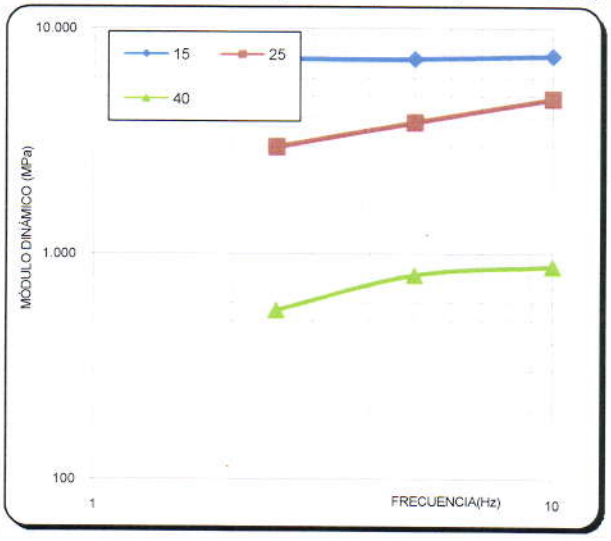
Localización: PLANTA CENTRASA **Fecha de Ensayo:** Reporta resultado

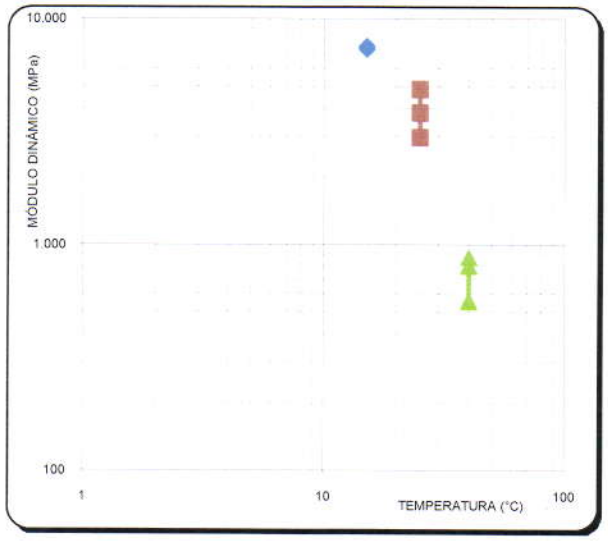
Muestra: PROBETA No. 3 y No. 5 **Almacenamiento:** Ambiente

Deformación Objetivo 5µm Tipo de probeta: Marshall Edad 15 días

BRIQUETA	TEMP. (°C)	FREC. (Hz)	MÓDULO (MPa) Diámetro 1	MÓDULO (MPa) Diámetro 2	Variación %	Módulo Promedio (MPa)	OBSERVACIONES
5	15	10,00	7.317	7.678	-4,7	7.498	
5	15	5,00	6.929	7.621	-9,1	7.275	
5	15	2,50	7.154	7.465	-4,2	7.310	
3	25	10,00	4.691	5.049	-7,1	4.870	
3	25	5,00	3.699	3.972	-6,9	3.836	
3	25	2,50	2.871	3.117	-7,9	2.994	
5	40	10,00	863	884	-2,4	874	
5	40	5,00	829	768	7,9	799	
5	40	2,50	566	544	4,0	555	

Nota 1: La prueba se realiza sobre los dos diámetros perpendiculares. El valor del Módulo corresponde al promedio de los dos valores, con una variación permisible entre -20 y +10% respecto a la primera medida (UNE-EN 12697-26).





OBSERVACIONES

La variación entre diámetros perpendiculares NO supera el criterio de la norma EN para una prueba. Se anexan resultados.

EJECUTÓ: LABORATORIO

REVISÓ: DIRECCIÓN TÉCNICA

ADMINISTRADORA DE PROYECTOS CIVILES SAS
Calle 154 n 17 78 Bogotá, D.C.
teléfonos 527 0376 - 626 1884
servicios@apcltda.net
contacto@apcltda.net

ENSAYO DE MÓDULO DE RIGIDEZ - CURVA MAESTRA

INSTRUCTIVO:IE-AF3-01 PROCEDIMIENTO DE ENSAYO: EN 12697:2004 ANEXO C

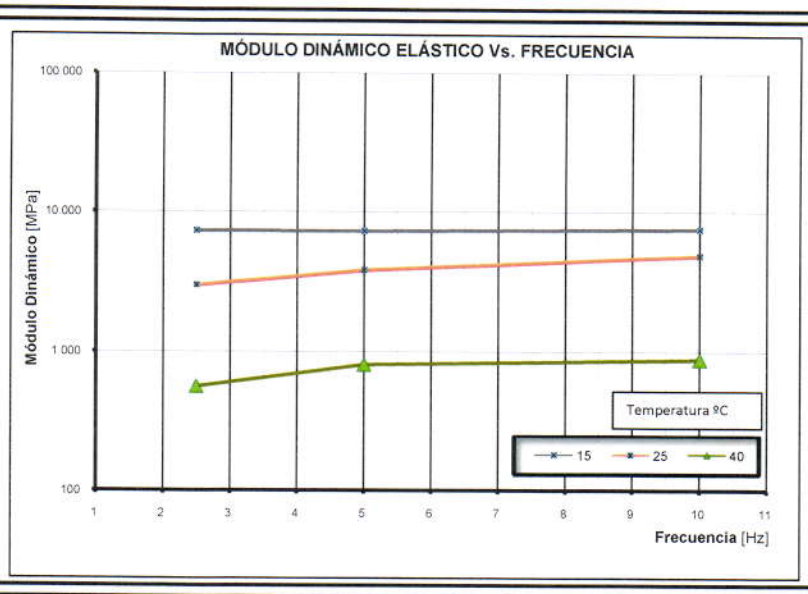
CÓDIGO ORDEN: 116 **PROYECTO:** MODULOS CENTRASA

Tipo de mezcla:
Localización: PLANTA CENTRASA
Muestra: PROBETA No. 3 y No. 5
Fecha Recepción: *14-dic-11*
Fecha de Ensayo: ***Reporta resultado***
Almacenamiento: Ambiente

Ts = 25 °C

T [°C]	f [Hz]	X	Módulo Dinámico [MPa]
15	10,00	5,24	7.498
	5,00	4,54	7.275
	2,50	3,85	7.310
25	10,00	2,30	4.870
	5,00	1,61	3.836
	2,50	0,92	2.994
40	10,00	-1,75	874
	5,00	-2,44	799
	2,50	-3,13	555

ISOTERMAS

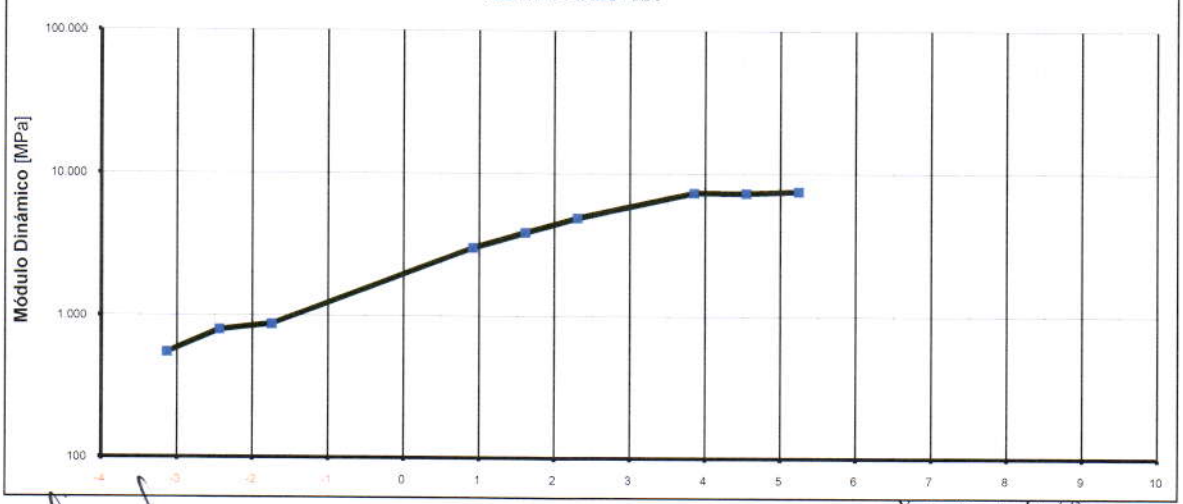


$$X = \alpha_T + Ln\,(f)$$

$$\alpha_T = 2{,}52 \cdot 10^{-4} \cdot \left(\frac{1}{T} - \frac{1}{T_s}\right)$$

α_T = factor de modificación en función de la temperatura.
X = Parámetro de reducción de la Curva Maestra.
f = frecuencia de la prueba en Hz.
T= Temperatura absoluta de la prueba (T=T°C+273,15).
Ts= Temperatura absoluta de referencia (Ts=Ts°C+273,15).

CURVA MAESTRA



OBSERVACIONES:

EJECUTÓ: LABORATORISTA

REVISÓ: ING. DE LABORATORIO

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-05 F10Hz

Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
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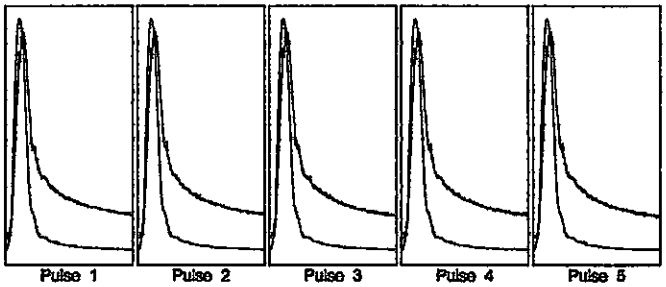
.

Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-05 F10 Hz
Test temperature:	15°C
Specimen diameter:	102,1 mm
Specimen thickness:	62,2 mm
Bulk density:	2198 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	33 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 08:59	Client name :	CENTRASA S.A

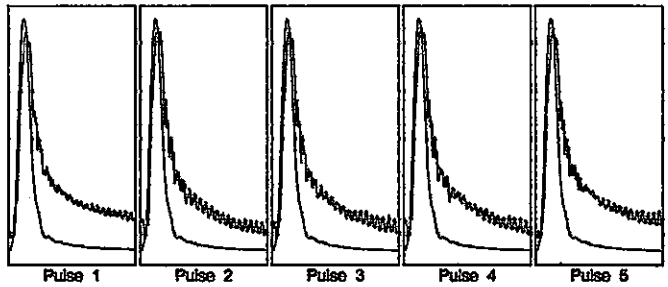
Type and origin of the the bituminous mixture	MDC-1
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		4,04	4,06	4,05
Horizontal stress (kPa)		404,8	407,4	406,5
Load-area factor	0,60	0,62	0,63	0,63
Horizontal deformation (µm)	5,0	5,6	5,7	5,6
Load (rise) time (ms):	33	26,0	27,0	26,8
Measured stiffness modulus (MPa)		7082	7294	7189
Adjusted stiffness modulus (MPa)		7207	7378	7317

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		3,69	3,67	3,68
Horizontal stress (kPa)		368,8	367,7	367,3
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	4,8	5,0	4,8
Load (rise) time (ms):	33	28,0	29,0	28,4
Measured stiffness modulus (MPa)		7271	7931	7653
Adjusted stiffness modulus (MPa)		7329	7982	7678

Mean results of the two tests

Load (rise) time (ms):	:	27,6
Horizontal deformation (µm)	:	5,2
Horizontal deformation (%)	:	0,0051
Measured stiffness modulus (MPa)	:	7421
Adjusted stiffness modulus (MPa)	:	7498

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (-5)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-05 F5 Hz

Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
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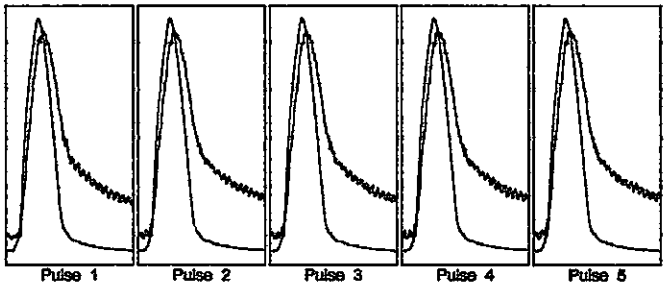
Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-05 F5 Hz
Test temperature:	15°C
Specimen diameter:	102,1 mm
Specimen thickness:	62,2 mm
Bulk density:	2198 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	63 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 09:04	Client name :	CENTRASA S.A

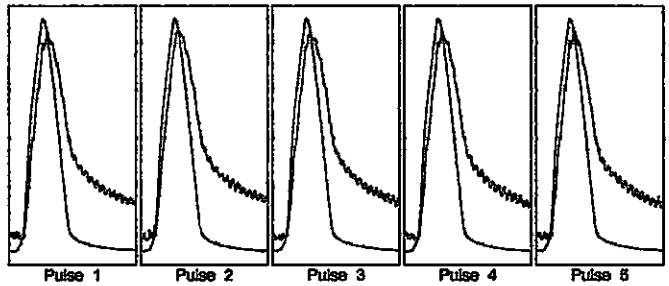
Type and origin of the the bituminous mixture	MDC-1
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		3,43	3,45	3,44
Horizontal stress (kPa)		344,3	348,0	344,9
Load-area factor	0,60	0,62	0,62	0,62
Horizontal deformation (µm)	5,0	4,9	5,1	5,0
Load (rise) time (ms):	63	58,0	60,0	58,8
Measured stiffness modulus (MPa)		6758	6938	6835
Adjusted stiffness modulus (MPa)		6849	7031	6929

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		3,67	3,70	3,69
Horizontal stress (kPa)		367,9	371,0	369,6
Load-area factor	0,60	0,61	0,61	0,61
Horizontal deformation (µm)	5,0	4,8	4,9	4,8
Load (rise) time (ms):	63	60,0	62,0	61,6
Measured stiffness modulus (MPa)		7535	7619	7589
Adjusted stiffness modulus (MPa)		7559	7656	7621

Mean results of the two tests

Load (rise) time (ms):	:	60,1
Horizontal deformation (µm)	:	4,9
Horizontal deformation (%)	:	0,0048
Measured stiffness modulus (MPa)	:	7211
Adjusted stiffness modulus (MPa)	:	7275

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (-10)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-05F2.5Hz

Address of testing laboratory

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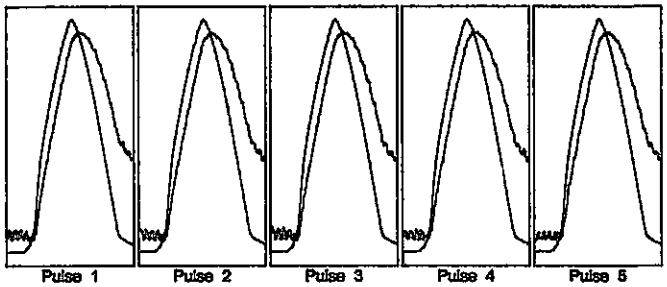
Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-05 F2.5 Hz
Test temperature:	15°C
Specimen diameter:	102,1 mm
Specimen thickness:	62,2 mm
Bulk density:	2198 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	124 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 09:09	Client name :	CENTRASA S.A

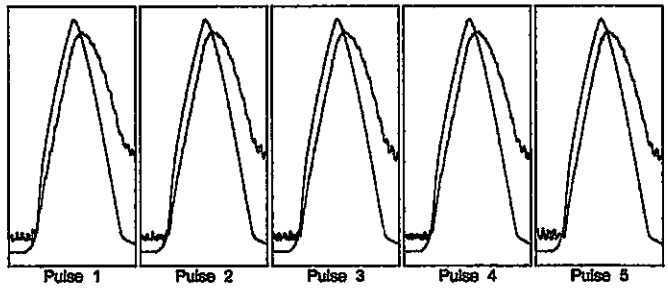
Type and origin of the the bituminous mixture	MDC-1
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		3,50	3,52	3,51
Horizontal stress (kPa)		350,6	352,9	351,7
Load-area factor	0.60	0,60	0,63	0,61
Horizontal deformation (µm)	5,0	4,9	5,0	4,9
Load (rise) time (ms):	124	122,0	129,0	124,8
Measured stiffness modulus (MPa)		6993	7218	7096
Adjusted stiffness modulus (MPa)		7055	7334	7164

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		3,66	3,68	3,68
Horizontal stress (kPa)		367,4	369,3	368,5
Load-area factor	0.60	0,59	0,61	0,61
Horizontal deformation (µm)	5,0	4,8	5,0	4,9
Load (rise) time (ms):	124	122,0	126,0	123,0
Measured stiffness modulus (MPa)		7256	7629	7441
Adjusted stiffness modulus (MPa)		7227	7661	7465

Mean results of the two tests

Load (rise) time (ms):	:	123,9
Horizontal deformation (µm)	:	4,9
Horizontal deformation (%)	:	0,0048
Measured stiffness modulus (MPa)	:	7269
Adjusted stiffness modulus (MPa)	:	7310

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (-4)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-03 F10Hz

Address of testing laboratory

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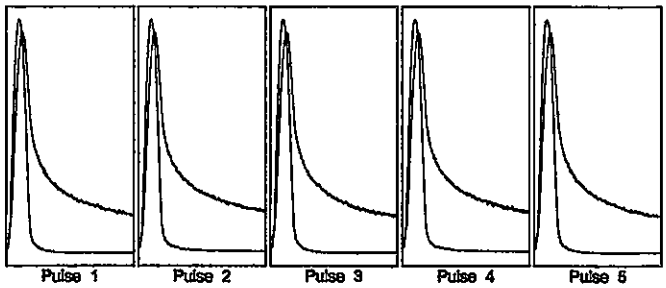
Date of print-out:	18:01:2012
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-03 F10 Hz
Test temperature:	25°C
Specimen diameter:	102,2 mm
Specimen thickness:	61,2 mm
Bulk density:	2207 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	33 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	18:Ene:2012 12:41	Client name :	CENTRASA S.A.

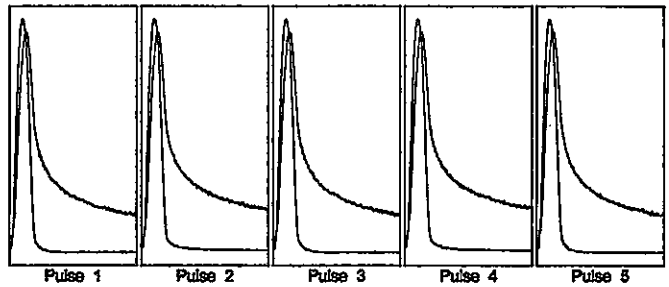
Type and origin of the the bituminous mixture	MDC-1
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	INV. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		2,31	2,35	2,33
Horizontal stress (kPa)		238,2	239,5	237,5
Load-area factor	0.60	0,59	0,62	0,61
Horizontal deformation (µm)	5,0	5,0	5,1	5,0
Load (rise) time (ms):	33	30,0	31,0	30,6
Measured stiffness modulus (MPa)		4688	4745	4716
Adjusted stiffness modulus (MPa)		4689	4773	4735

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		2,30	2,35	2,32
Horizontal stress (kPa)		234,1	239,1	236,3
Load-area factor	0.60	0,59	0,62	0,61
Horizontal deformation (µm)	5,0	5,0	5,2	5,1
Load (rise) time (ms):	33	31,0	33,0	31,8
Measured stiffness modulus (MPa)		4608	4642	4633
Adjusted stiffness modulus (MPa)		4626	4672	4648

Mean results of the two tests

Load (rise) time (ms):	:	31,2
Horizontal deformation (µm)	:	5,0
Horizontal deformation (%)	:	0,0049
Measured stiffness modulus (MPa)	:	4675
Adjusted stiffness modulus (MPa)	:	4691

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (2)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 18:01:2012

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-03 F5Hz

Date of print-out:	18:01:2012
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-03 F5 Hz
Test temperature:	25°C
Specimen diameter:	102,2 mm
Specimen thickness:	61,2 mm
Bulk density:	2207 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	63 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Address of testing laboratory

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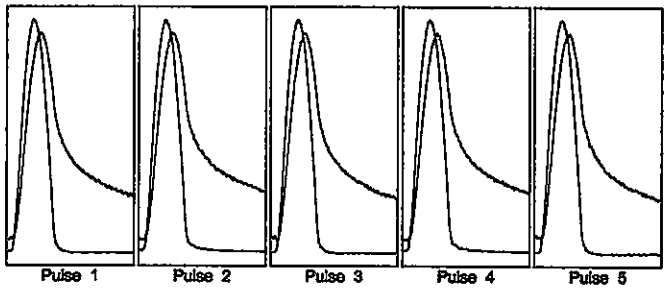
Date & time of test :	18:Ene:2012 12:47	Client name :	CENTRASA S.A.

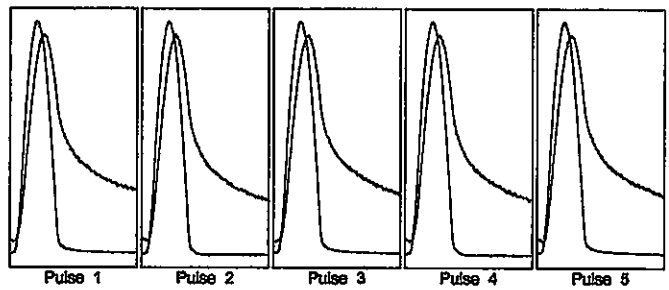
Type and origin of the the bituminous mixture	MDC-1
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	INV. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,83	1,88	1,85
Horizontal stress (kPa)		188,2	191,4	188,3
Load-area factor	0.60	0,60	0,62	0,61
Horizontal deformation (µm)	5,0	4,9	5,2	5,1
Load (rise) time (ms):	63	61,0	63,0	62,4
Measured stiffness modulus (MPa)		3643	3760	3710
Adjusted stiffness modulus (MPa)		3683	3788	3731

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,83	1,89	1,87
Horizontal stress (kPa)		186,6	192,4	190,1
Load-area factor	0.60	0,60	0,61	0,60
Horizontal deformation (µm)	5,0	5,1	5,3	5,2
Load (rise) time (ms):	63	61,0	63,0	62,4
Measured stiffness modulus (MPa)		3633	3678	3660
Adjusted stiffness modulus (MPa)		3635	3692	3687

Mean results of the two tests

Load (rise) time (ms):	:	62,4
Horizontal deformation (µm)	:	5,1
Horizontal deformation (%)	:	0,0050
Measured stiffness modulus (MPa)	:	3685
Adjusted stiffness modulus (MPa)	:	3699

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (2)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 18:01:2012

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-03F2.5Hz

Address of testing laboratory

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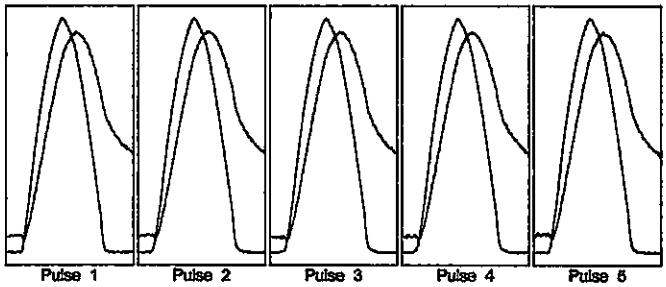
Date of print-out:	18:01:2012
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-03 F2.5 Hz
Test temperature:	25°C
Specimen diameter:	102,2 mm
Specimen thickness:	61,2 mm
Bulk density:	2207 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	124 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	18:Ene:2012 12:53	Client name :	CENTRASA S.A.

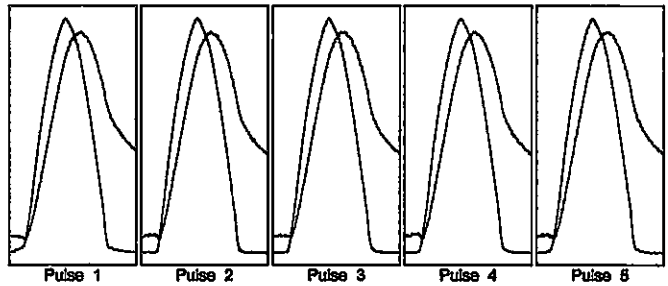
Type and origin of the the bituminous mixture	MDC-1
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	INV. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,44	1,46	1,45
Horizontal stress (kPa)		148,4	148,4	147,6
Load-area factor	0,60	0,59	0,60	0,60
Horizontal deformation (µm)	5,0	5,1	5,1	5,1
Load (rise) time (ms):	124	125,0	128,0	126,0
Measured stiffness modulus (MPa)		2871	2896	2885
Adjusted stiffness modulus (MPa)		2865	2900	2880

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,45	1,49	1,47
Horizontal stress (kPa)		147,4	151,7	149,2
Load-area factor	0,60	0,59	0,60	0,60
Horizontal deformation (µm)	5,0	5,1	5,3	5,2
Load (rise) time (ms):	124	124,0	127,0	125,4
Measured stiffness modulus (MPa)		2844	2888	2867
Adjusted stiffness modulus (MPa)		2835	2891	2862

Mean results of the two tests

Load (rise) time (ms):	:	125,7
Horizontal deformation (µm)	:	5,1
Horizontal deformation (%)	:	0,0050
Measured stiffness modulus (MPa)	:	2876
Adjusted stiffness modulus (MPa)	:	2871

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (0,6)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 18:01:2012

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-5 F10 Hz

Address of testing laboratory

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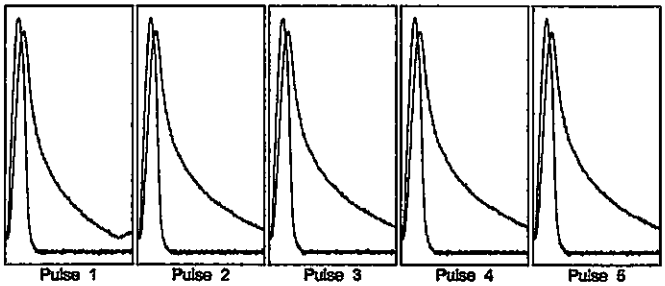
Date of print-out:	21:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-05 F10 Hz
Test temperature:	40°C
Specimen diameter:	102,1 mm
Specimen thickness:	62,2 mm
Bulk density:	2198 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	33 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	21:Dic:2011 08:08	Client name :	CENTRASA S.A

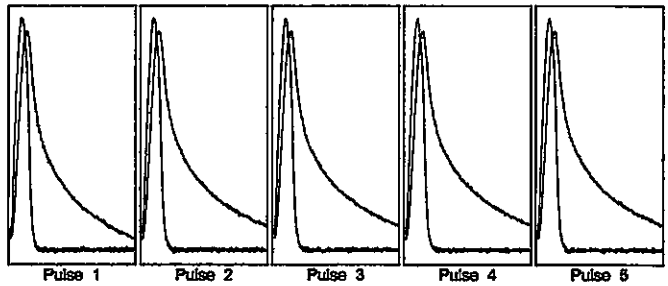
Type and origin of the the bituminous mixture	MDC-1
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,48	0,48	0,47
Horizontal stress (kPa)		48,6	47,9	47,3
Load-area factor	0,60	0,58	0,63	0,59
Horizontal deformation (µm)	5,0	5,0	5,6	5,4
Load (rise) time (ms):	33	34,0	36,0	35,0
Measured stiffness modulus (MPa)		841	928	865
Adjusted stiffness modulus (MPa)		836	940	883

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,46	0,47	0,46
Horizontal stress (kPa)		48,3	48,7	48,5
Load-area factor	0,60	0,58	0,61	0,60
Horizontal deformation (µm)	5,0	4,9	5,3	5,2
Load (rise) time (ms):	33	32,0	38,0	34,2
Measured stiffness modulus (MPa)		870	933	885
Adjusted stiffness modulus (MPa)		866	937	884

Mean results of the two tests

Load (rise) time (ms):	:	34,6
Horizontal deformation (µm)	:	5,3
Horizontal deformation (%)	:	0,0052
Measured stiffness modulus (MPa)	:	875
Adjusted stiffness modulus (MPa)	:	874

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (-2)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 21:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-5 F5 Hz

Date of print-out:	21:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-05 F5 Hz
Test temperature:	40°C
Specimen diameter:	102,1 mm
Specimen thickness:	62,2 mm
Bulk density:	2198 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	63 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Address of testing laboratory

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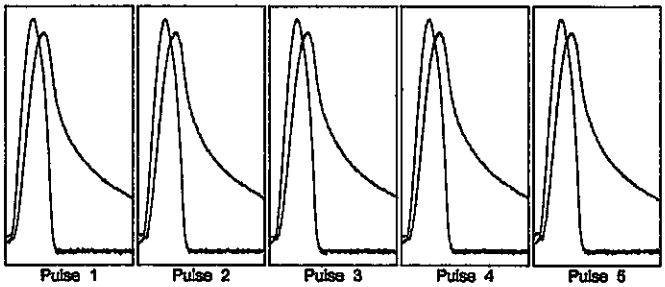
Date & time of test :	21:Dic:2011 08:21	Client name :	CENTRASA S.A

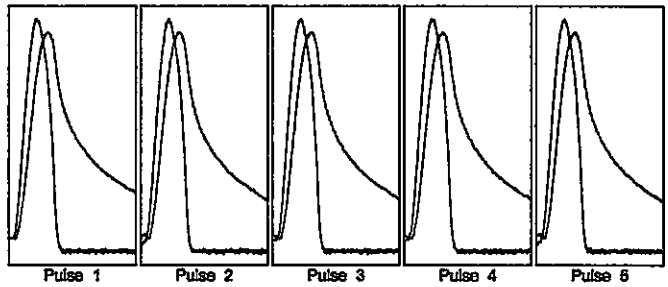
Type and origin of the the bituminous mixture	MDC-1
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,44	0,44	0,44
Horizontal stress (kPa)		43,6	44,4	43,9
Load-area factor	0,60	0,58	0,61	0,60
Horizontal deformation (µm)	5,0	5,1	5,4	5,3
Load (rise) time (ms):	63	62,0	66,0	64,0
Measured stiffness modulus (MPa)		817	855	830
Adjusted stiffness modulus (MPa)		811	856	829

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,42	0,44	0,43
Horizontal stress (kPa)		42,6	43,7	42,9
Load-area factor	0,60	0,58	0,60	0,59
Horizontal deformation (µm)	5,0	5,4	5,7	5,5
Load (rise) time (ms):	63	64,0	65,0	64,8
Measured stiffness modulus (MPa)		760	779	769
Adjusted stiffness modulus (MPa)		758	778	768

Mean results of the two tests

Load (rise) time (ms):	:	64,4
Horizontal deformation (µm)	:	5,4
Horizontal deformation (%)	:	0,0053
Measured stiffness modulus (MPa)	:	800
Adjusted stiffness modulus (MPa)	:	799

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (7)

Person responsible for this test report	Signed
LUTHER HERRERA	Date of issue of report: 21:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-5 F2.5Hz

Address of testing laboratory

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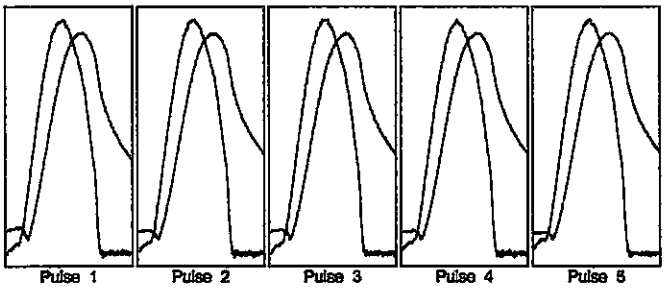
Date of print-out:	21:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-05 F2.5 Hz
Test temperature:	40°C
Specimen diameter:	102,1 mm
Specimen thickness:	62,2 mm
Bulk density:	2198 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	124 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	21:Dic:2011 08:30	Client name :	CENTRASA S.A

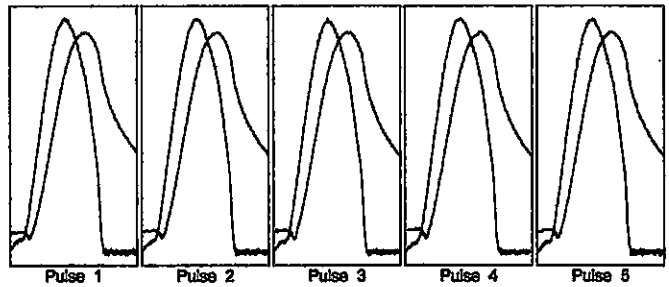
Type and origin of the the bituminous mixture	MDC-1
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,30	0,31	0,31
Horizontal stress (kPa)		30,8	31,5	31,0
Load-area factor	0,60	0,60	0,62	0,61
Horizontal deformation (µm)	5,0	5,1	5,7	5,5
Load (rise) time (ms):	124	126,0	132,0	129,2
Measured stiffness modulus (MPa)		550	600	565
Adjusted stiffness modulus (MPa)		550	600	568

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,30	0,31	0,30
Horizontal stress (kPa)		30,3	30,7	30,5
Load-area factor	0,60	0,58	0,60	0,59
Horizontal deformation (µm)	5,0	6,5	5,7	5,6
Load (rise) time (ms):	124	119,0	132,0	123,8
Measured stiffness modulus (MPa)		536	553	548
Adjusted stiffness modulus (MPa)		533	553	544

Mean results of the two tests

Load (rise) time (ms):	:	126,5
Horizontal deformation (µm)	:	5,5
Horizontal deformation (%)	:	0,0054
Measured stiffness modulus (MPa)	:	556
Adjusted stiffness modulus (MPa)	:	555

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (4)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 21:12:2011

ADMINISTRADORA DE PROYECTOS CIVILES SAS
Calle 154 No. 17-78 Bogotá, D.C.
teléfonos 527 0376 - 626 1884
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Formato ASF-02

ENSAYO DE MÓDULO DE RIGIDEZ DINÁMICO - MEZCLA ASFÁLTICA

INSTRUCTIVO:IE-AF2-01 PROCEDIMIENTO DE ENSAYO: EN 12697:2004 ANEXO C

CÓDIGO ORDEN: 116 **PROYECTO:** MODULOS CENTRASA

Tipo de mezcla: MDC-2 - INVIAS **Fecha Recepción:** 14-dic-11

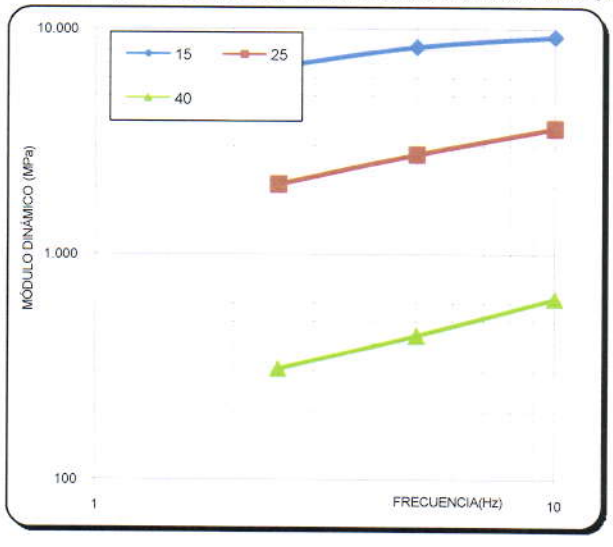
Localización: PLANTA CENTRASA **Fecha de Ensayo:** Reporta resultado

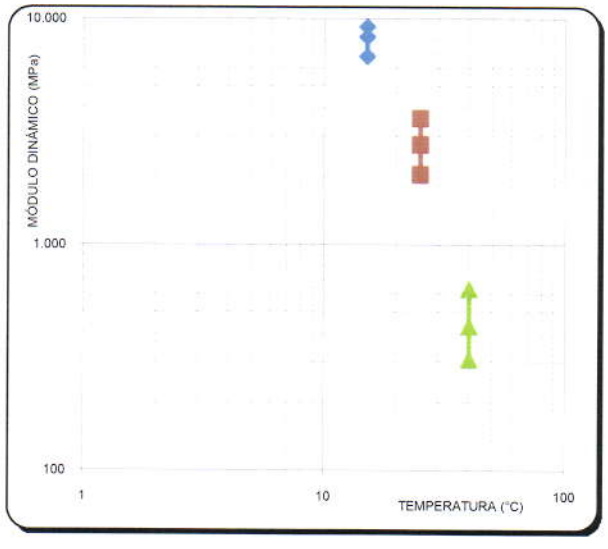
Muestra: 10 **Almacenamiento:** Ambiente

Deformación Objetivo 5µm Tipo de probeta: Marshall Edad 15 días

BRIQUETA	TEMP. (°C)	FREC. (Hz)	MÓDULO (MPa) Diámetro 1	MÓDULO (MPa) Diámetro 2	Variación %	Módulo Promedio (MPa)	OBSERVACIONES
10	15	10,00	9.094	9.181	-0,9	9.138	
10	15	5,00	8.220	8.195	0,3	8.208	
10	15	2,50	6.764	6.672	1,4	6.718	
10	25	10,00	3.587	3.585	0,1	3.586	
10	25	5,00	2.787	2.729	2,1	2.758	
10	25	2,50	2.042	2.034	0,4	2.038	
10	40	10,00	624	632	-1,3	628	
10	40	5,00	427	431	-0,9	429	
10	40	2,50	316	298	6,0	307	

Nota 1: La prueba se realiza sobre los dos diámetros perpendiculares. El valor del Módulo corresponde al promedio de los dos valores, con una variación permisible entre -20 y +10% respecto a la primera medida (UNE-EN 12697-26).





OBSERVACIONES: La variación entre diámetros perpendiculares NO supera el criterio de la norma EN para una prueba. Se anexan resultados.

EJECUTÓ: LABORATORIO

REVISÓ: DIRECCIÓN TÉCNICA

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Formato ASF-03

ENSAYO DE MÓDULO DE RIGIDEZ - CURVA MAESTRA

INSTRUCTIVO:IE-AF3-01 PROCEDIMIENTO DE ENSAYO: EN 12697:2004 ANEXO C

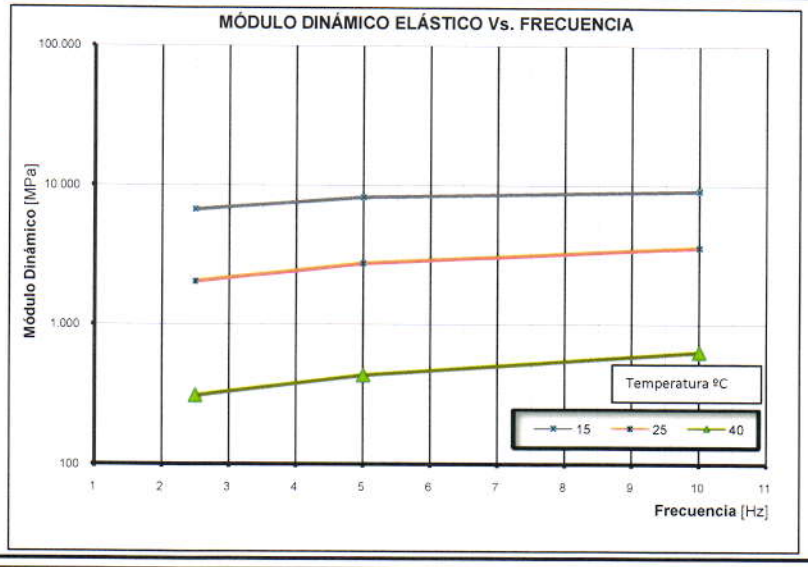
CÓDIGO ORDEN: 116 **PROYECTO:** MODULOS CENTRASA

Tipo de mezcla:
Localización: PLANTA CENTRASA
Muestra: 10
Fecha Recepción: 14-dic-11
Fecha de Ensayo: *Reporta resultado*
Almacenamiento: Ambiente

Ts = 25 °C

T [°C]	f [Hz]	X	Módulo Dinámico [MPa]
15	10,00	5,24	9.138
	5,00	4,54	8.208
	2,50	3,85	6.718
25	10,00	2,30	3.586
	5,00	1,61	2.758
	2,50	0,92	2.038
40	10,00	-1,75	628
	5,00	-2,44	429
	2,50	-3,13	307

ISOTERMAS

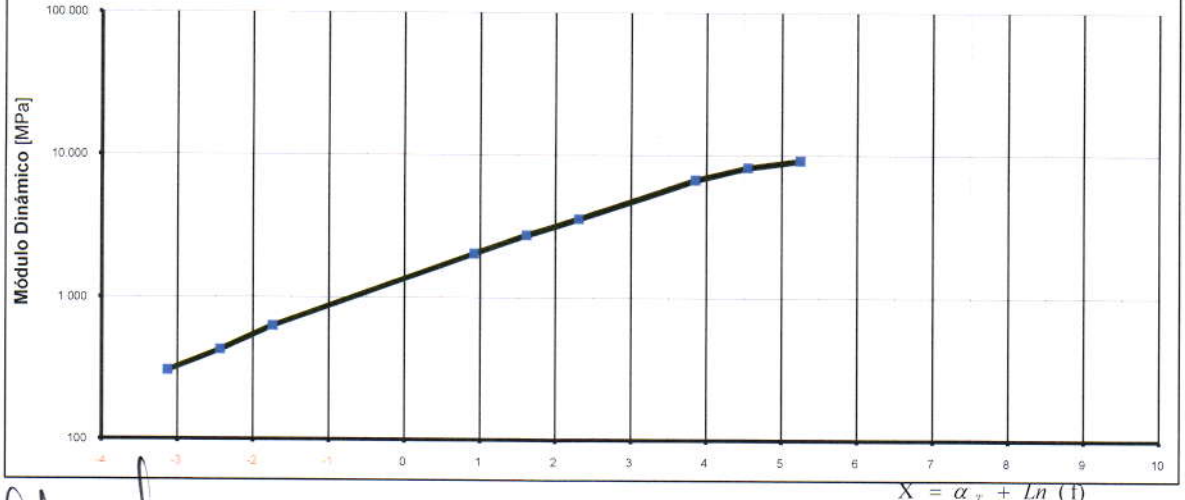


$$X = \alpha_T + Ln(f)$$

$$\alpha_T = 2{,}52 \cdot 10^{-4} \cdot \left(\frac{1}{T} - \frac{1}{T_s}\right)$$

α X = Parámetro de reducción de la Curva Maestra.
α_T = factor de modificación en función de la temperatura.
f = frecuencia de la prueba en Hz.
T= Temperatura absoluta de la prueba (T=T°C+273,15).
Ts= Temperatura absoluta de referencia (Ts=Ts°C+273,15).

CURVA MAESTRA



OBSERVACIONES:

EJECUTÓ: LABORATORISTA

REVISÓ: ING. DE LABORATORIO

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-10 F10Hz

Address of testing laboratory

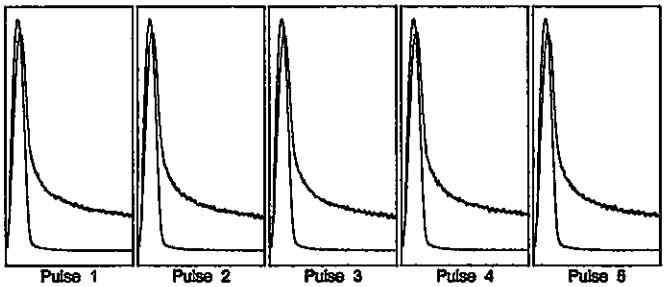
APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
.
.

Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-10 F10 Hz
Test temperature:	15°C
Specimen diameter:	102 mm
Specimen thickness:	61 mm
Bulk density:	2134 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	33 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 09:23	Client name :	CENTRASA S.A

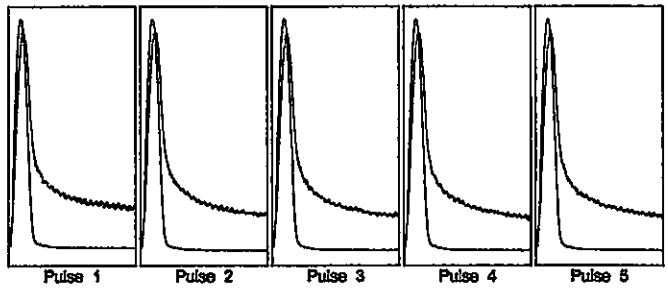
Type and origin of the the bituminous mixture	MDC-2
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		4,46	4,46	4,46
Horizontal stress (kPa)		456,2	456,8	456,5
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	4,9	5,1	5,0
Load (rise) time (ms):	33	32,0	33,0	32,8
Measured stiffness modulus (MPa)		8970	9243	9048
Adjusted stiffness modulus (MPa)		8975	9308	9094

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		4,51	4,57	4,53
Horizontal stress (kPa)		461,9	467,1	463,1
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,0	5,1	5,0
Load (rise) time (ms):	33	32,0	33,0	32,6
Measured stiffness modulus (MPa)		9065	9238	9152
Adjusted stiffness modulus (MPa)		9119	9274	9181

Mean results of the two tests

Load (rise) time (ms):	:	32,7
Horizontal deformation (µm)	:	5,0
Horizontal deformation (%)	:	0,0049
Measured stiffness modulus (MPa)	:	9100
Adjusted stiffness modulus (MPa)	:	9138

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (-1,0)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-10 F5 Hz

Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
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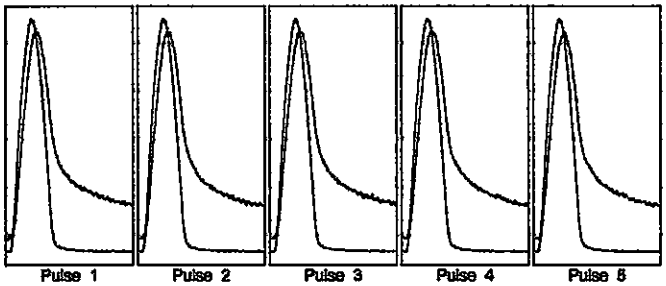
Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-10 F5 Hz
Test temperature:	15°C
Specimen diameter:	102 mm
Specimen thickness:	61 mm
Bulk density:	2134 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	63 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 09:38	Client name :	CENTRASA S.A

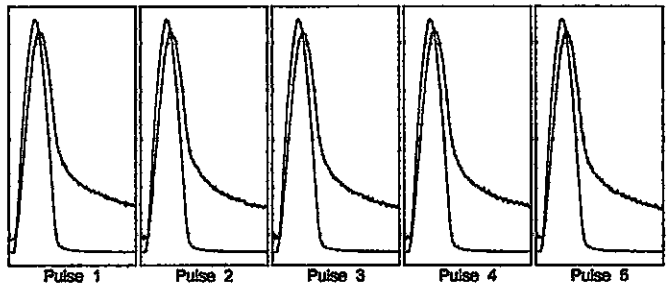
Type and origin of the the bituminous mixture	MDC-2
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		4,03	4,03	4,03
Horizontal stress (kPa)		412,2	412,8	412,4
Load-area factor	0,60	0,60	0,61	0,60
Horizontal deformation (µm)	5,0	4,9	5,0	5,0
Load (rise) time (ms):	63	62,0	63,0	62,6
Measured stiffness modulus (MPa)		8127	8309	8200
Adjusted stiffness modulus (MPa)		8139	8290	8220

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		4,00	4,01	4,01
Horizontal stress (kPa)		409,4	410,8	409,8
Load-area factor	0,60	0,60	0,61	0,60
Horizontal deformation (µm)	5,0	5,0	5,0	5,0
Load (rise) time (ms):	63	62,0	64,0	63,0
Measured stiffness modulus (MPa)		8128	8211	8173
Adjusted stiffness modulus (MPa)		8138	8258	8195

Mean results of the two tests

Load (rise) time (ms):	:	62,8
Horizontal deformation (µm)	:	5,0
Horizontal deformation (%)	:	0,0049
Measured stiffness modulus (MPa)	:	8187
Adjusted stiffness modulus (MPa)	:	8208

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (0,3)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-10F2.5Hz

Address of testing laboratory

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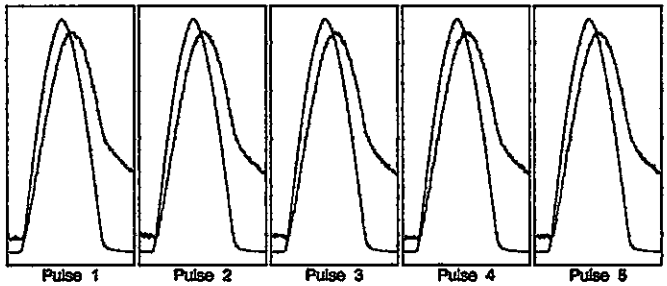
Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-10 F2.5 Hz
Test temperature:	15°C
Specimen diameter:	102 mm
Specimen thickness:	61 mm
Bulk density:	2134 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	124 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 09:45	Client name :	CENTRASA S.A

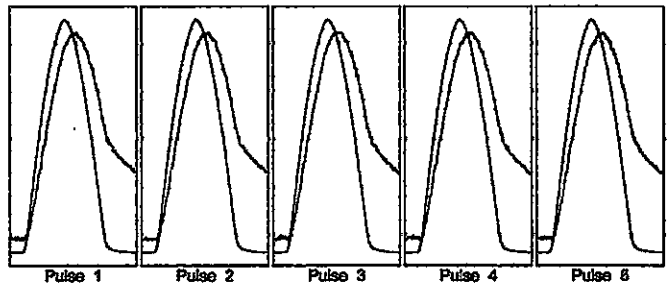
Type and origin of the the bituminous mixture	MDC-2
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		3,35	3,38	3,35
Horizontal stress (kPa)		342,6	343,3	342,9
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,0	5,1	5,1
Load (rise) time (ms):	124	124,0	125,0	124,2
Measured stiffness modulus (MPa)		6700	6767	6735
Adjusted stiffness modulus (MPa)		6701	6801	6764

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		3,28	3,28	3,28
Horizontal stress (kPa)		335,7	338,0	335,9
Load-area factor	0,60	0,60	0,61	0,60
Horizontal deformation (µm)	5,0	5,0	5,0	5,0
Load (rise) time (ms):	124	124,0	125,0	124,6
Measured stiffness modulus (MPa)		6628	6708	6656
Adjusted stiffness modulus (MPa)		6648	6714	6672

Mean results of the two tests

Load (rise) time (ms):	:	124,4
Horizontal deformation (µm)	:	5,0
Horizontal deformation (%)	:	0,0049
Measured stiffness modulus (MPa)	:	6696
Adjusted stiffness modulus (MPa)	:	6718

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (1)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-10 F10Hz

Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
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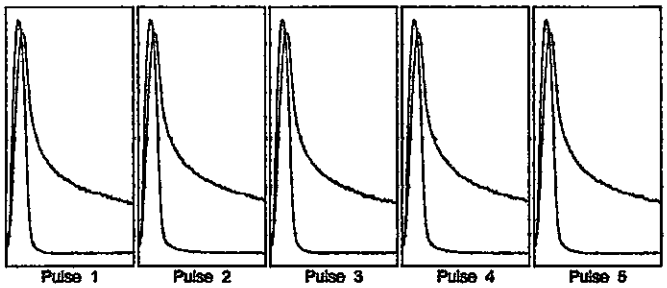
Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-10 F10 Hz
Test temperature:	25°C
Specimen diameter:	102 mm
Specimen thickness:	61 mm
Bulk density:	2134 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	33 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 16:40	Client name :	CENTRASA S.A

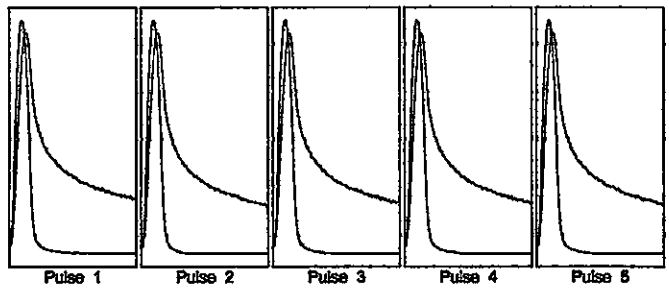
Type and origin of the the bituminous mixture	MDC-2
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,77	1,81	1,79
Horizontal stress (kPa)		181,1	185,3	183,6
Load-area factor	0,60	0,60	0,61	0,60
Horizontal deformation (µm)	5,0	4,9	5,2	5,1
Load (rise) time (ms):	33	31,0	33,0	31,6
Measured stiffness modulus (MPa)		3560	3634	3586
Adjusted stiffness modulus (MPa)		3559	3626	3587

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,79	1,81	1,80
Horizontal stress (kPa)		182,9	185,0	184,3
Load-area factor	0,60	0,59	0,62	0,61
Horizontal deformation (µm)	5,0	5,0	5,2	5,1
Load (rise) time (ms):	33	32,0	33,0	32,6
Measured stiffness modulus (MPa)		3557	3615	3570
Adjusted stiffness modulus (MPa)		3540	3660	3585

Mean results of the two tests

Load (rise) time (ms):	:	32,1
Horizontal deformation (µm)	:	5,1
Horizontal deformation (%)	:	0,0050
Measured stiffness modulus (MPa)	:	3578
Adjusted stiffness modulus (MPa)	:	3586

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (0,06)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-10 F5Hz

Address of testing laboratory

APC LTDA.
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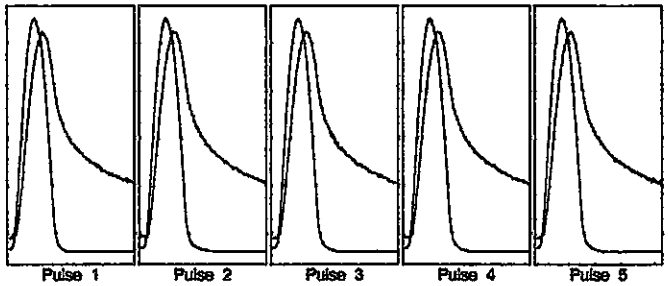
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
.
.

Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-10 F5 Hz
Test temperature:	25°C
Specimen diameter:	102 mm
Specimen thickness:	61 mm
Bulk density:	2134 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	63 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 16:45	Client name :	CENTRASA S.A

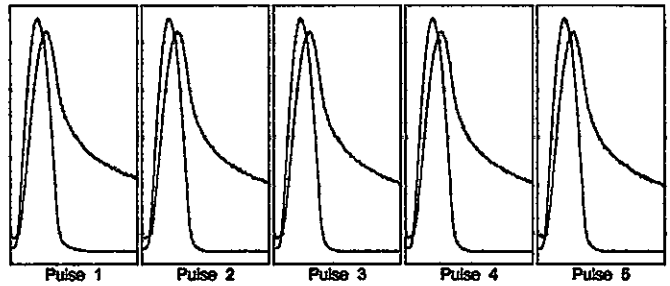
Type and origin of the the bituminous mixture	MDC-2
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,38	1,40	1,39
Horizontal stress (kPa)		139,4	143,6	142,1
Load-area factor	0.60	0,60	0,62	0,61
Horizontal deformation (µm)	5,0	4,9	5,2	5,1
Load (rise) time (ms):	63	62,0	65,0	63,4
Measured stiffness modulus (MPa)		2731	2810	2774
Adjusted stiffness modulus (MPa)		2746	2830	2787

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,39	1,42	1,40
Horizontal stress (kPa)		142,1	144,9	143,2
Load-area factor	0.60	0,59	0,62	0,61
Horizontal deformation (µm)	5,0	5,2	5,3	5,2
Load (rise) time (ms):	63	61,0	64,0	62,2
Measured stiffness modulus (MPa)		2694	2738	2719
Adjusted stiffness modulus (MPa)		2710	2750	2729

Mean results of the two tests

Load (rise) time (ms):	:	62,8
Horizontal deformation (µm)	:	5,2
Horizontal deformation (%)	:	0,0051
Measured stiffness modulus (MPa)	:	2747
Adjusted stiffness modulus (MPa)	:	2758

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (2)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-10F2.5Hz

Address of testing laboratory

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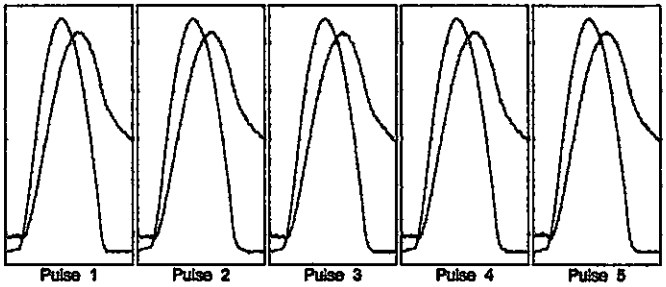
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
.
.

Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-10 F2.5 Hz
Test temperature:	25°C
Specimen diameter:	102 mm
Specimen thickness:	61 mm
Bulk density:	2134 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	124 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 16:49	Client name :	CENTRASA S.A

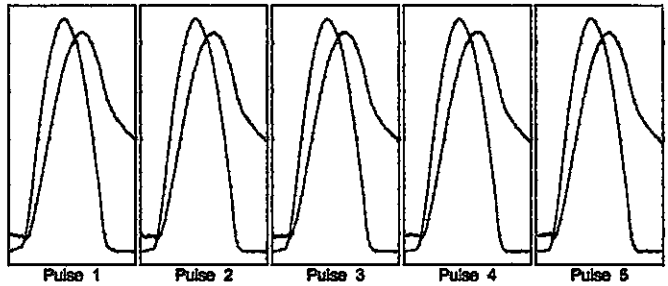
Type and origin of the the bituminous mixture	MDC-2
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,02	1,05	1,04
Horizontal stress (kPa)		104,4	107,9	106,5
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,1	5,3	5,2
Load (rise) time (ms):	124	125,0	128,0	126,0
Measured stiffness modulus (MPa)		2018	2052	2035
Adjusted stiffness modulus (MPa)		2026	2059	2042

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,02	1,04	1,03
Horizontal stress (kPa)		104,6	106,8	105,5
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,1	5,3	5,2
Load (rise) time (ms):	124	122,0	126,0	124,0
Measured stiffness modulus (MPa)		2012	2044	2028
Adjusted stiffness modulus (MPa)		2021	2045	2034

Mean results of the two tests

Load (rise) time (ms):	:	125,0
Horizontal deformation (µm)	:	5,2
Horizontal deformation (%)	:	0,0051
Measured stiffness modulus (MPa)	:	2032
Adjusted stiffness modulus (MPa)	:	2038

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (0,4)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-10 F10Hz

Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
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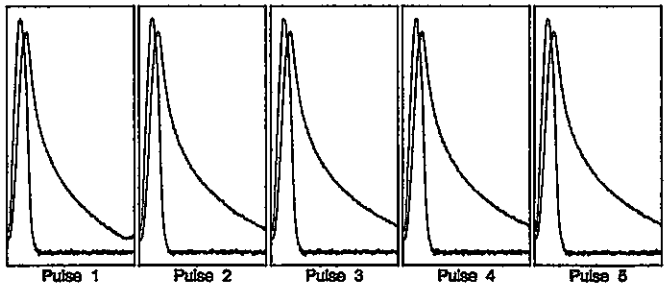
.

Date of print-out:	21:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-10 F10 Hz
Test temperature:	40°C
Specimen diameter:	102 mm
Specimen thickness:	61 mm
Bulk density:	2134 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	33 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	21:Dic:2011 08:37	Client name :	CENTRASA S.A

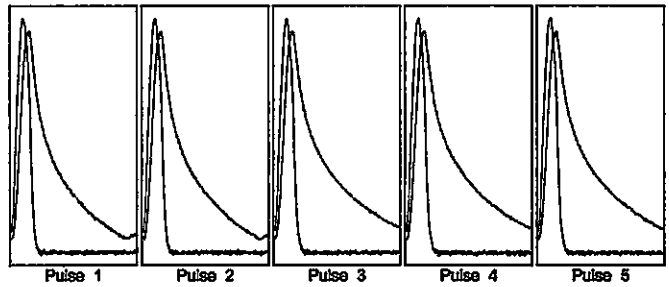
Type and origin of the the bituminous mixture	MDC-2
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,34	0,35	0,34
Horizontal stress (kPa)		34,6	35,4	34,9
Load-area factor	0.60	0,57	0,60	0,59
Horizontal deformation (µm)	5,0	5,1	5,8	5,5
Load (rise) time (ms):	33	33,0	38,0	34,8
Measured stiffness modulus (MPa)		604	668	629
Adjusted stiffness modulus (MPa)		605	667	624

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,34	0,35	0,35
Horizontal stress (kPa)		35,1	36,2	35,8
Load-area factor	0.60	0,60	0,61	0,60
Horizontal deformation (µm)	5,0	5,3	5,8	5,6
Load (rise) time (ms):	33	31,0	35,0	33,6
Measured stiffness modulus (MPa)		612	673	632
Adjusted stiffness modulus (MPa)		612	672	632

Mean results of the two tests

Load (rise) time (ms):	:	34,2
Horizontal deformation (µm)	:	5,6
Horizontal deformation (%)	:	0,0055
Measured stiffness modulus (MPa)	:	629
Adjusted stiffness modulus (MPa)	:	628

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (-1)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 21:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-10 F5Hz

Address of testing laboratory

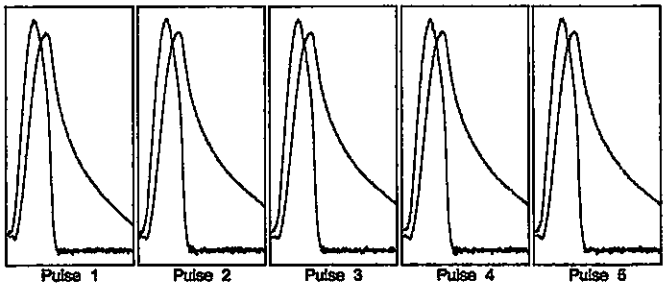
APC LTDA.
Calle 154 n 17 - 78
Tel (57-1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
.
.

Date of print-out:	21:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-10 F5 Hz
Test temperature:	40°C
Specimen diameter:	102 mm
Specimen thickness:	61 mm
Bulk density:	2134 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	63 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	21:Dic:2011 08:42	Client name :	CENTRASA S.A

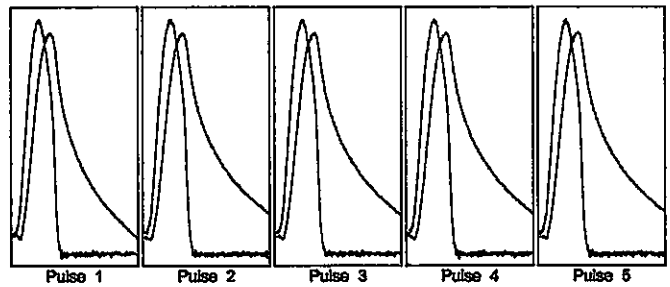
Type and origin of the the bituminous mixture	MDC-2
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,24	0,26	0,24
Horizontal stress (kPa)		24,6	25,3	24,9
Load-area factor	0.60	0,58	0,61	0,60
Horizontal deformation (µm)	5,0	5,2	6,1	5,8
Load (rise) time (ms):	63	61,0	65,0	63,2
Measured stiffness modulus (MPa)		410	471	426
Adjusted stiffness modulus (MPa)		408	471	427

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,26	0,26	0,26
Horizontal stress (kPa)		25,1	25,5	25,3
Load-area factor	0.60	0,60	0,62	0,61
Horizontal deformation (µm)	5,0	5,1	6,2	5,9
Load (rise) time (ms):	63	62,0	66,0	63,8
Measured stiffness modulus (MPa)		411	489	431
Adjusted stiffness modulus (MPa)		412	489	431

Mean results of the two tests

Load (rise) time (ms):	:	63,4
Horizontal deformation (µm)	:	5,8
Horizontal deformation (%)	:	0,0057
Measured stiffness modulus (MPa)	:	429
Adjusted stiffness modulus (MPa)	:	429

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (-0,9)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 21:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-10F2.5Hz

Address of testing laboratory

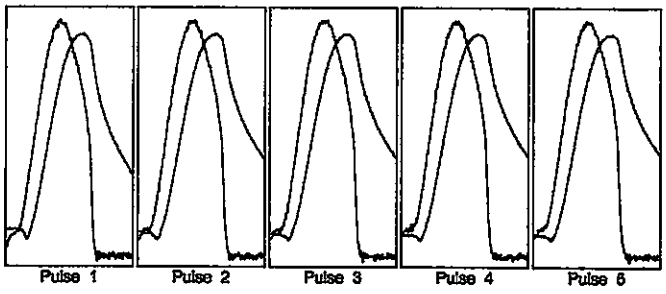
APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net

Date of print-out:	21:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-10 F2.5 Hz
Test temperature:	40°C
Specimen diameter:	102 mm
Specimen thickness:	61 mm
Bulk density:	2134 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	124 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	21:Dic:2011 08:48	Client name :	CENTRASA S.A

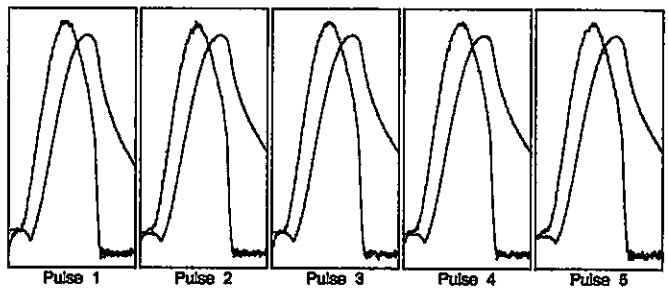
Type and origin of the the bituminous mixture	MDC-2
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20ºC
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,18	0,20	0,20
Horizontal stress (kPa)		18,8	20,9	20,0
Load-area factor	0,60	0,59	0,63	0,60
Horizontal deformation (µm)	5,0	5,3	6,9	6,3
Load (rise) time (ms):	124	112,0	128,0	122,8
Measured stiffness modulus (MPa)		300	354	316
Adjusted stiffness modulus (MPa)		300	353	316

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,17	0,19	0,18
Horizontal stress (kPa)		17,6	19,1	18,5
Load-area factor	0,60	0,58	0,61	0,60
Horizontal deformation (µm)	5,0	5,3	6,5	6,2
Load (rise) time (ms):	124	125,0	141,0	131,8
Measured stiffness modulus (MPa)		288	329	298
Adjusted stiffness modulus (MPa)		288	329	298

Mean results of the two tests

Load (rise) time (ms):	:	127,3
Horizontal deformation (µm)	:	6,3
Horizontal deformation (%)	:	0,0061
Measured stiffness modulus (MPa)	:	307
Adjusted stiffness modulus (MPa)	:	307

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (6)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 21:12:2011

ADMINISTRADORA DE PROYECTOS CIVILES SAS
Calle 154 No. 17-78 Bogotá, D.C.
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Formato ASF-02

ENSAYO DE MÓDULO DE RIGIDEZ DINÁMICO - MEZCLA ASFÁLTICA

INSTRUCTIVO:IE-AF2-01 PROCEDIMIENTO DE ENSAYO: EN 12697:2004 ANEXO C

CÓDIGO ORDEN: 116 **PROYECTO:** MODULOS CENTRASA

Tipo de mezcla: MD12 - IDU **Fecha Recepción:** 14-dic-11

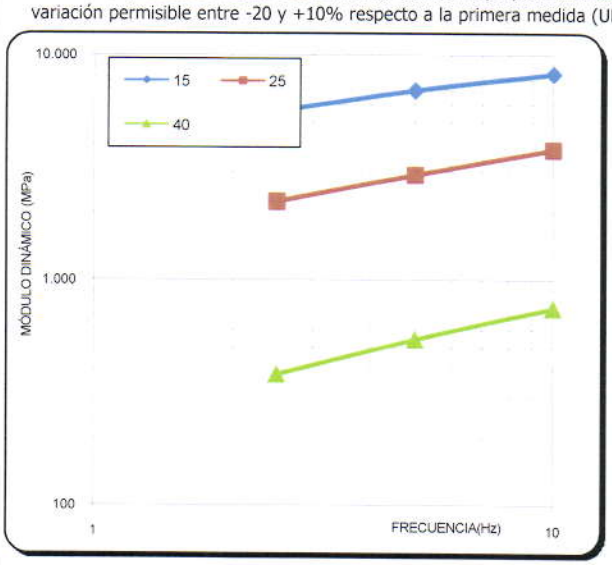
Localización: PLANTA CENTRASA **Fecha de Ensayo:** **Reporta resultado**

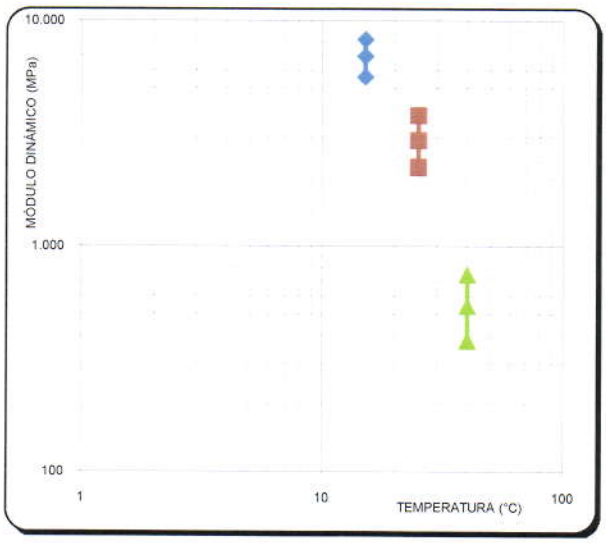
Muestra: 6 **Almacenamiento:** Ambiente

Deformación Objetivo 5µm Tipo de probeta: Marshall Edad 15 días

BRIQUETA	TEMP. (°C)	FREC. (Hz)	MÓDULO (MPa) Diámetro 1	MÓDULO (MPa) Diámetro 2	Variación %	Módulo Promedio (MPa)	OBSERVACIONES
6	15	10,00	8.322	8.076	3,0	8.199	
6	15	5,00	6.922	6.879	0,6	6.901	
6	15	2,50	5.615	5.542	1,3	5.579	
6	25	10,00	3.796	3.741	1,5	3.769	
6	25	5,00	2.939	2.894	1,6	2.917	
6	25	2,50	2.236	2.202	1,5	2.219	
6	40	10,00	756	736	2,7	746	
6	40	5,00	547	537	1,9	542	
6	40	2,50	395	362	9,1	379	

Nota 1: La prueba se realiza sobre los dos diámetros perpendiculares. El valor del Módulo corresponde al promedio de los dos valores, con una variación permisible entre -20 y +10% respecto a la primera medida (UNE-EN 12697-26).





OBSERVACIONES

La variación entre diámetros perpendiculares NO supera el criterio de la norma EN para una prueba. Se anexan resultados.

EJECUTÓ: LABORATORIO

REVISÓ: DIRECCIÓN TÉCNICA

ADMINISTRADORA DE PROYECTOS CIVILES SAS
Calle 154 n 17 78
teléfonos
servicios@apcltda.net
contacto@apcltda.net
Bogotá, D.C.
527 0376 - 626 1884

Formato ASF-03

ENSAYO DE MÓDULO DE RIGIDEZ - CURVA MAESTRA

INSTRUCTIVO:IE-AF3-01 PROCEDIMIENTO DE ENSAYO: EN 12697:2004 ANEXO C

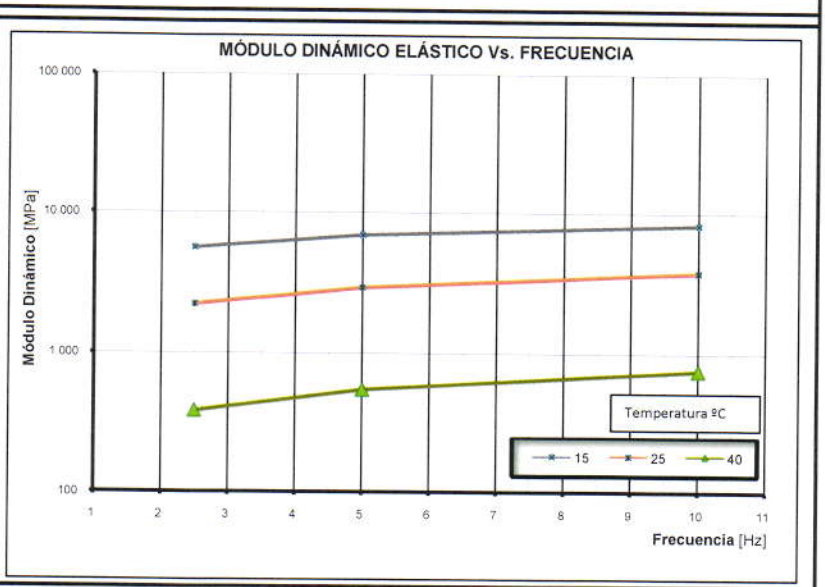
CÓDIGO ORDEN: 116 **PROYECTO:** MODULOS CENTRASA

Tipo de mezcla:
Localización: PLANTA CENTRASA
Muestra: 6
Fecha Recepción: 14-dic-11
Fecha de Ensayo: *Reporta resultado*
Almacenamiento: Ambiente

Ts = 25 °C

T [°C]	f [Hz]	X	Módulo Dinámico [MPa]
15	10,00	5,24	8.199
	5,00	4,54	6.901
	2,50	3,85	5.579
25	10,00	2,30	3.769
	5,00	1,61	2.917
	2,50	0,92	2.219
40	10,00	-1,75	746
	5,00	-2,44	542
	2,50	-3,13	379

ISOTERMAS

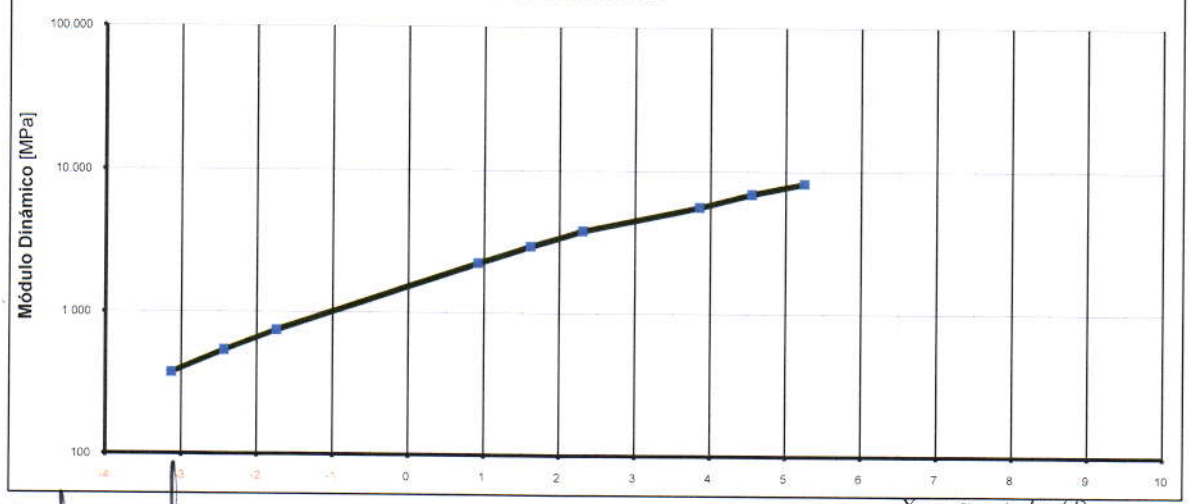


$$X = \alpha_T + Ln\,(f)$$

$$\alpha_T = 2{,}52 \cdot 10^{4} \cdot \left(\frac{1}{T} - \frac{1}{T_s}\right)$$

α X = Parámetro de reducción de la Curva Maestra.
α_T = factor de modificación en función de la temperatura.
f = frecuencia de la prueba en Hz.
T= Temperatura absoluta de la prueba (T=T°C+273,15).
Ts= Temperatura absoluta de referencia (Ts=Ts°C+273,15).

CURVA MAESTRA



$$X = \alpha_T + Ln\,(f)$$

OBSERVACIONES:

EJECUTÓ: LABORATORISTA

REVISÓ: ING. DE LABORATORIO

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-6 F10Hz

Address of testing laboratory

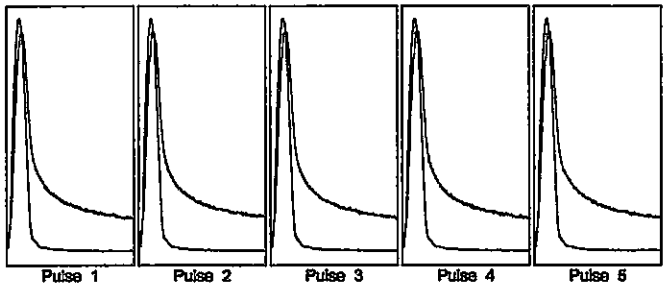
APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
.
.

Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-06 F10 Hz
Test temperature:	15°C
Specimen diameter:	102,2 mm
Specimen thickness:	61 mm
Bulk density:	2246 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	33 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 10:03	Client name :	CENTRASA S.A

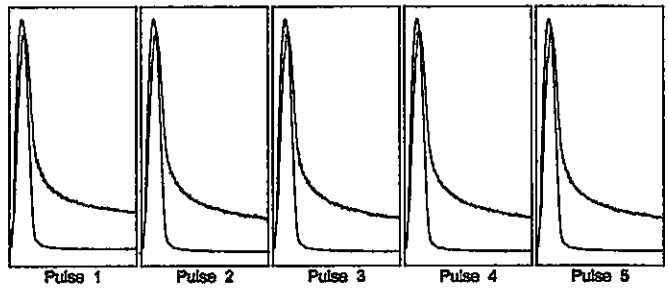
Type and origin of the the bituminous mixture	MD-12
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		4,05	4,07	4,06
Horizontal stress (kPa)		413,9	415,2	414,5
Load-area factor	0,60	0,59	0,60	0,60
Horizontal deformation (µm)	5,0	4,9	5,0	5,0
Load (rise) time (ms):	33	32,0	33,0	32,8
Measured stiffness modulus (MPa)		8244	8391	8329
Adjusted stiffness modulus (MPa)		8216	8399	8322

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		3,94	3,99	3,95
Horizontal stress (kPa)		402,5	407,2	403,7
Load-area factor	0,60	0,60	0,61	0,60
Horizontal deformation (µm)	5,0	5,0	5,1	5,0
Load (rise) time (ms):	33	32,0	34,0	32,8
Measured stiffness modulus (MPa)		8022	8083	8064
Adjusted stiffness modulus (MPa)		8018	8100	8076

Mean results of the two tests

Load (rise) time (ms):	:	32,8
Horizontal deformation (µm)	:	5,0
Horizontal deformation (%)	:	0,0049
Measured stiffness modulus (MPa)	:	8197
Adjusted stiffness modulus (MPa)	:	8199

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (3)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-6 F5 Hz

Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
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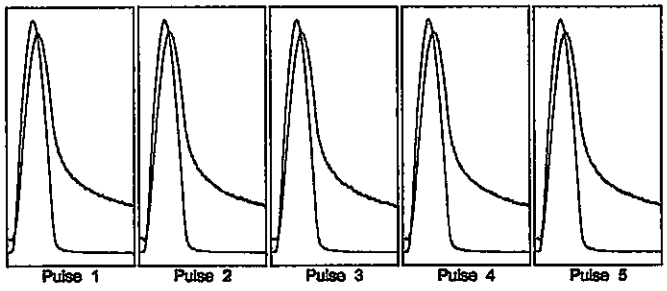
.

Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-06 F5 Hz
Test temperature:	15°C
Specimen diameter:	102,2 mm
Specimen thickness:	61 mm
Bulk density:	2246 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	63 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 10:08	Client name :	CENTRASA S.A

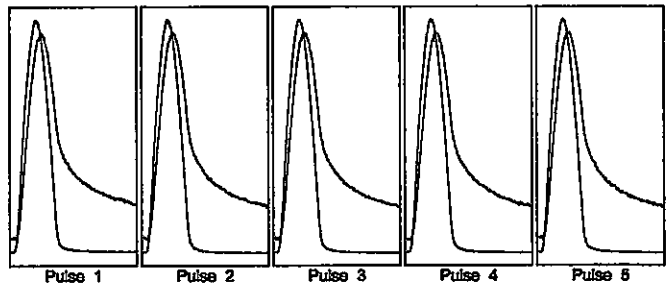
Type and origin of the the bituminous mixture	MD-12
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		3,39	3,40	3,40
Horizontal stress (kPa)		346,5	347,2	346,8
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,0	5,0	5,0
Load (rise) time (ms):	63	62,0	63,0	62,2
Measured stiffness modulus (MPa)		6866	6928	6892
Adjusted stiffness modulus (MPa)		6887	6951	6922

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		3,35	3,39	3,37
Horizontal stress (kPa)		342,0	346,6	344,3
Load-area factor	0,60	0,60	0,61	0,60
Horizontal deformation (µm)	5,0	5,0	5,0	5,0
Load (rise) time (ms):	63	62,0	63,0	62,6
Measured stiffness modulus (MPa)		6835	6900	6871
Adjusted stiffness modulus (MPa)		6849	6926	6879

Mean results of the two tests

Load (rise) time (ms):	:	62,4
Horizontal deformation (µm)	:	5,0
Horizontal deformation (%)	:	0,0049
Measured stiffness modulus (MPa)	:	6882
Adjusted stiffness modulus (MPa)	:	6901

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (0,6)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-6 F2.5Hz

Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
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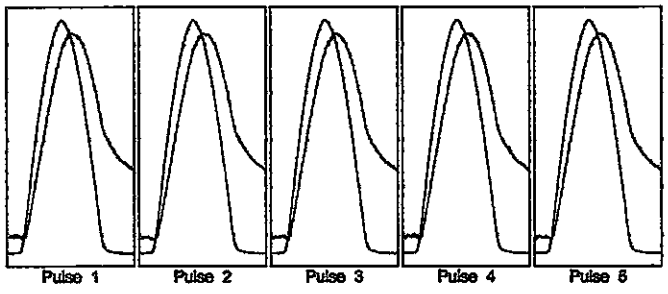
Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-06 F2.5 Hz
Test temperature:	15°C
Specimen diameter:	102,2 mm
Specimen thickness:	61 mm
Bulk density:	2246 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	124 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 10:12	Client name :	CENTRASA S.A

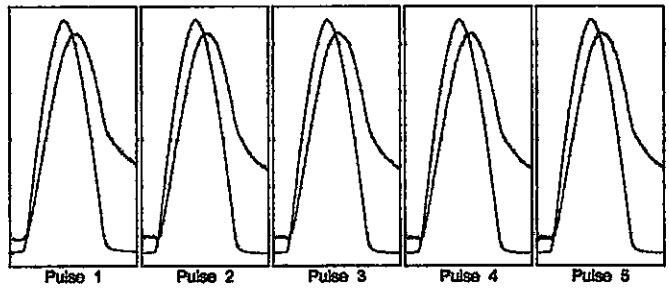
Type and origin of the the bituminous mixture	MD-12
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		2,75	2,76	2,76
Horizontal stress (kPa)		280,8	281,8	281,2
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,0	5,0	5,0
Load (rise) time (ms):	124	122,0	127,0	124,4
Measured stiffness modulus (MPa)		5562	5612	5587
Adjusted stiffness modulus (MPa)		5588	5637	5615

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		2,73	2,77	2,74
Horizontal stress (kPa)		279,2	282,7	280,1
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,0	5,2	5,1
Load (rise) time (ms):	124	122,0	126,0	123,8
Measured stiffness modulus (MPa)		5437	5575	5511
Adjusted stiffness modulus (MPa)		5484	5619	5542

Mean results of the two tests

Load (rise) time (ms):	:	124,1
Horizontal deformation (µm)	:	5,0
Horizontal deformation (%)	:	0,0049
Measured stiffness modulus (MPa)	:	5549
Adjusted stiffness modulus (MPa)	:	5579

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (1)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-6 F10 Hz

Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
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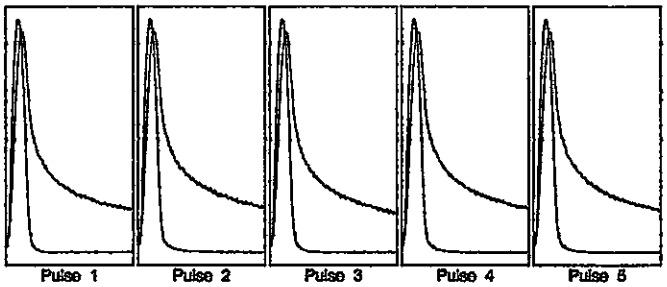
.

Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-06 F10 Hz
Test temperature:	25°C
Specimen diameter:	102,2 mm
Specimen thickness:	61 mm
Bulk density:	2246 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	33 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 16:16	Client name :	CENTRASA S.A

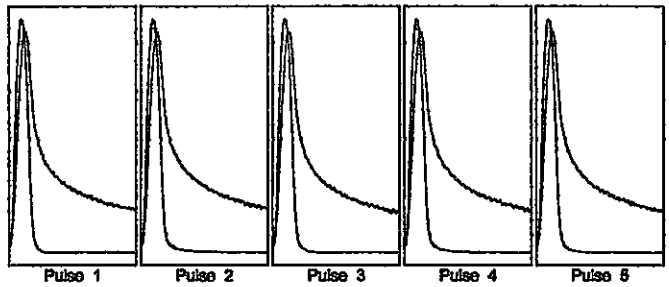
Type and origin of the the bituminous mixture	MD-12
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20ºC
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,88	1,90	1,88
Horizontal stress (kPa)		189,6	193,6	192,3
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,0	5,1	5,1
Load (rise) time (ms):	33	31,0	33,0	32,6
Measured stiffness modulus (MPa)		3739	3818	3779
Adjusted stiffness modulus (MPa)		3757	3833	3796

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,88	1,90	1,88
Horizontal stress (kPa)		189,8	193,9	192,4
Load-area factor	0,60	0,59	0,61	0,60
Horizontal deformation (µm)	5,0	5,0	5,2	5,1
Load (rise) time (ms):	33	31,0	33,0	32,0
Measured stiffness modulus (MPa)		3682	3797	3745
Adjusted stiffness modulus (MPa)		3678	3779	3741

Mean results of the two tests

Load (rise) time (ms):	:	32,3
Horizontal deformation (µm)	:	5,1
Horizontal deformation (%)	:	0,0050
Measured stiffness modulus (MPa)	:	3762
Adjusted stiffness modulus (MPa)	:	3769

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (1)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-6 F5 Hz

Address of testing laboratory

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Bogotá D.C., Colombia
contacto@apcltda.net
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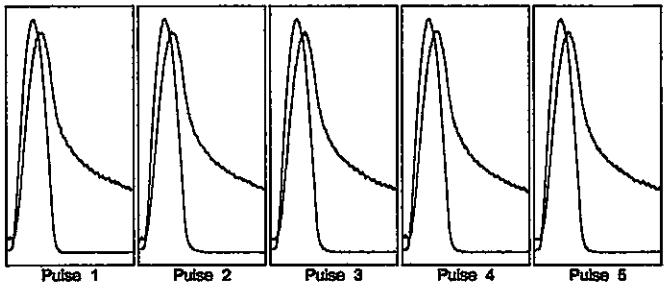
Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-06 F5 Hz
Test temperature:	25°C
Specimen diameter:	102,2 mm
Specimen thickness:	61 mm
Bulk density:	2246 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	63 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 16:21	Client name :	CENTRASA S.A

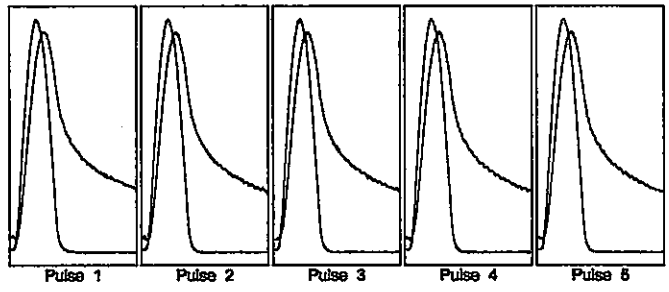
Type and origin of the the bituminous mixture	MD-12
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,45	1,49	1,47
Horizontal stress (kPa)		147,6	151,9	150,3
Load-area factor	0,60	0,60	0,62	0,61
Horizontal deformation (µm)	5,0	4,9	5,2	5,1
Load (rise) time (ms):	63	62,0	64,0	63,0
Measured stiffness modulus (MPa)		2884	2973	2924
Adjusted stiffness modulus (MPa)		2897	2992	2939

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,46	1,48	1,47
Horizontal stress (kPa)		149,1	151,1	149,7
Load-area factor	0,60	0,60	0,61	0,60
Horizontal deformation (µm)	5,0	5,1	5,2	5,2
Load (rise) time (ms):	63	61,0	63,0	62,2
Measured stiffness modulus (MPa)		2871	2908	2890
Adjusted stiffness modulus (MPa)		2878	2910	2894

Mean results of the two tests

Load (rise) time (ms):	:	62,6
Horizontal deformation (µm)	:	5,1
Horizontal deformation (%)	:	0,0050
Measured stiffness modulus (MPa)	:	2907
Adjusted stiffness modulus (MPa)	:	2917

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (2)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-6 F2.5Hz

Address of testing laboratory

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Bogotá D.C., Colombia
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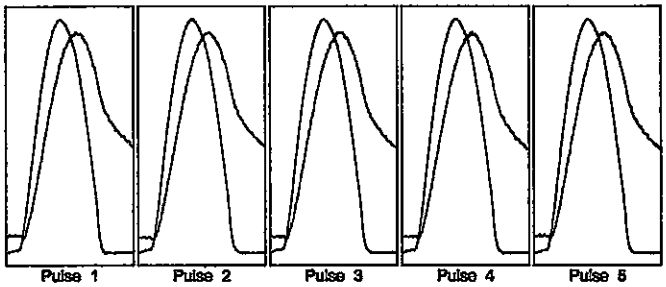
Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-06 F2.5 Hz
Test temperature:	25°C
Specimen diameter:	102,2 mm
Specimen thickness:	61 mm
Bulk density:	2246 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	124 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 16:26	Client name :	CENTRASA S.A

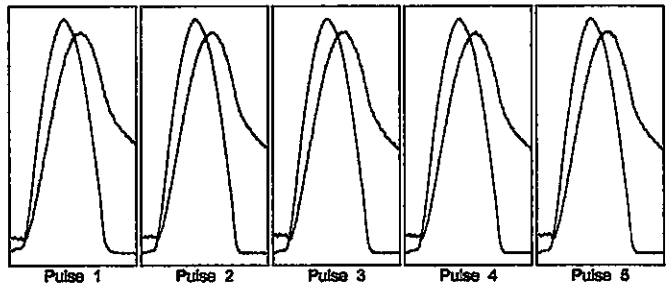
Type and origin of the the bituminous mixture	MD-12
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,12	1,14	1,13
Horizontal stress (kPa)		114,0	116,6	115,8
Load-area factor	0.60	0,60	0,62	0,61
Horizontal deformation (µm)	5,0	5,0	5,2	5,2
Load (rise) time (ms):	124	122,0	124,0	122,8
Measured stiffness modulus (MPa)		2210	2260	2226
Adjusted stiffness modulus (MPa)		2211	2262	2236

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,12	1,14	1,13
Horizontal stress (kPa)		113,9	116,9	115,0
Load-area factor	0.60	0,61	0,62	0,61
Horizontal deformation (µm)	5,0	5,1	5,4	5,2
Load (rise) time (ms):	124	122,0	127,0	124,4
Measured stiffness modulus (MPa)		2142	2217	2191
Adjusted stiffness modulus (MPa)		2149	2238	2202

Mean results of the two tests

Load (rise) time (ms):	:	123,6
Horizontal deformation (µm)	:	5,2
Horizontal deformation (%)	:	0,0051
Measured stiffness modulus (MPa)	:	2209
Adjusted stiffness modulus (MPa)	:	2219

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (2)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-6 F10Hz

Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
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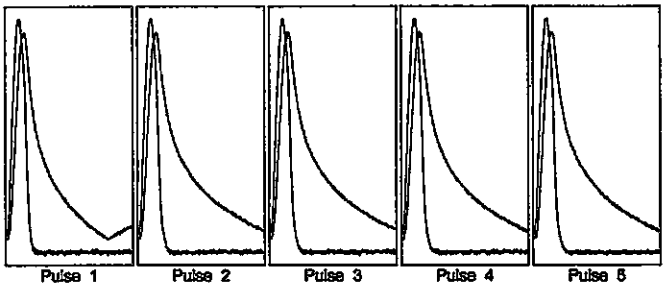
Date of print-out:	21:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-06 F10 Hz
Test temperature:	40°C
Specimen diameter:	102,2 mm
Specimen thickness:	61 mm
Bulk density:	2246 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	33 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	21:Dic:2011 09:21	Client name :	CENTRASA S.A

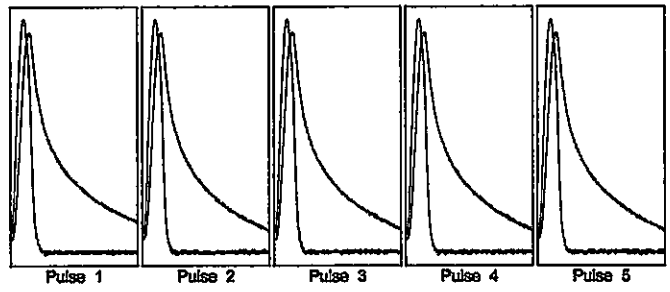
Type and origin of the the bituminous mixture	MD-12
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,40	0,42	0,41
Horizontal stress (kPa)		40,7	43,0	42,1
Load-area factor	0.60	0,57	0,59	0,58
Horizontal deformation (µm)	5,0	5,0	5,7	5,6
Load (rise) time (ms):	33	34,0	36,0	34,8
Measured stiffness modulus (MPa)		745	819	781
Adjusted stiffness modulus (MPa)		741	812	756

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,41	0,42	0,41
Horizontal stress (kPa)		41,9	42,6	42,1
Load-area factor	0.60	0,59	0,61	0,60
Horizontal deformation (µm)	5,0	5,6	5,8	5,7
Load (rise) time (ms):	33	34,0	37,0	36,0
Measured stiffness modulus (MPa)		728	745	735
Adjusted stiffness modulus (MPa)		731	744	738

Mean results of the two tests

Load (rise) time (ms):	:	35,4
Horizontal deformation (µm)	:	5,6
Horizontal deformation (%)	:	0,0055
Measured stiffness modulus (MPa)	:	748
Adjusted stiffness modulus (MPa)	:	746

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (3)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 21:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-6 F5Hz

Address of testing laboratory

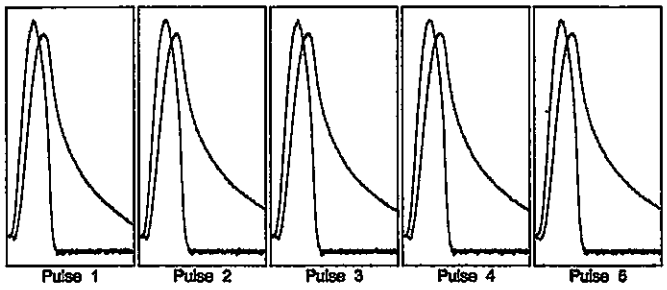
APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
.
.

Date of print-out:	21:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-06 F5 Hz
Test temperature:	40°C
Specimen diameter:	102,2 mm
Specimen thickness:	61 mm
Bulk density:	2246 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	63 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	21:Dic:2011 09:26	Client name :	CENTRASA S.A

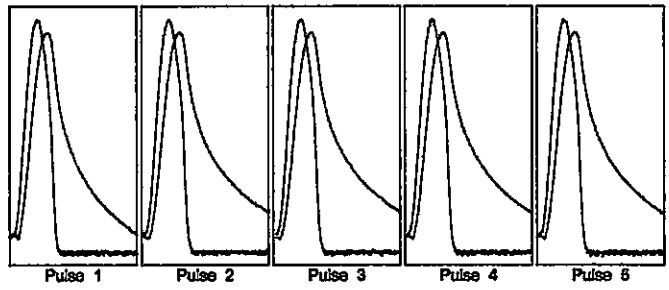
Type and origin of the the bituminous mixture	MD-12
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,30	0,31	0,31
Horizontal stress (kPa)		30,4	31,5	31,2
Load-area factor	0.60	0,59	0,62	0,60
Horizontal deformation (µm)	5,0	5,1	5,9	5,7
Load (rise) time (ms):	63	62,0	66,0	63,6
Measured stiffness modulus (MPa)		526	591	548
Adjusted stiffness modulus (MPa)		526	590	547

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,29	0,31	0,31
Horizontal stress (kPa)		29,9	31,6	31,1
Load-area factor	0.60	0,59	0,62	0,61
Horizontal deformation (µm)	5,0	5,0	6,0	5,8
Load (rise) time (ms):	63	60,0	68,0	64,2
Measured stiffness modulus (MPa)		519	591	537
Adjusted stiffness modulus (MPa)		518	598	537

Mean results of the two tests

Load (rise) time (ms):	:	63,9
Horizontal deformation (µm)	:	5,7
Horizontal deformation (%)	:	0,0056
Measured stiffness modulus (MPa)	:	542
Adjusted stiffness modulus (MPa)	:	542

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (2)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 21:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-6F2.5Hz

Address of testing laboratory

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Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
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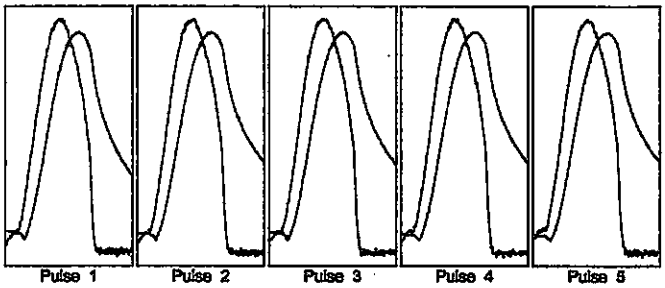
Date of print-out:	21:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-06 F2.5 Hz
Test temperature:	40°C
Specimen diameter:	102,2 mm
Specimen thickness:	61 mm
Bulk density:	2246 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	124 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	21:Dic:2011 09:31	Client name :	CENTRASA S.A

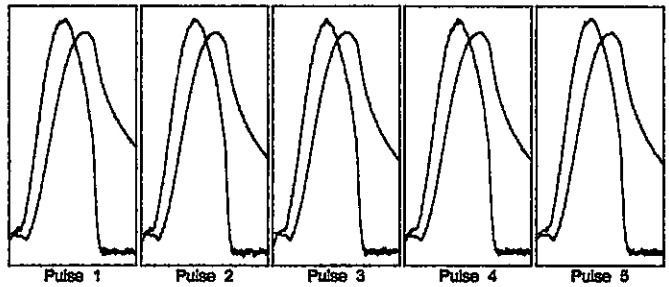
Type and origin of the the bituminous mixture	MD-12
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,22	0,25	0,24
Horizontal stress (kPa)		22,7	25,1	24,2
Load-area factor	0.60	0,57	0,62	0,61
Horizontal deformation (µm)	5,0	5,3	6,5	6,1
Load (rise) time (ms):	124	122,0	127,0	124,8
Measured stiffness modulus (MPa)		383	426	394
Adjusted stiffness modulus (MPa)		382	428	395

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,24	0,24	0,24
Horizontal stress (kPa)		24,2	24,6	24,4
Load-area factor	0.60	0,59	0,63	0,61
Horizontal deformation (µm)	5,0	6,6	7,2	6,7
Load (rise) time (ms):	124	116,0	130,0	122,8
Measured stiffness modulus (MPa)		338	370	361
Adjusted stiffness modulus (MPa)		340	371	362

Mean results of the two tests

Load (rise) time (ms):	:	123,8
Horizontal deformation (µm)	:	6,4
Horizontal deformation (%)	:	0,0063
Measured stiffness modulus (MPa)	:	378
Adjusted stiffness modulus (MPa)	:	379

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (8)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 21:12:2011

ADMINISTRADORA DE PROYECTOS CIVILES SAS
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Formato ASF-02

ENSAYO DE MÓDULO DE RIGIDEZ DINÁMICO - MEZCLA ASFÁLTICA

INSTRUCTIVO:IE-AF2-01

PROCEDIMIENTO DE ENSAYO: EN 12697:2004 ANEXO C

CÓDIGO ORDEN: 116 **PROYECTO:** MODULOS CENTRASA

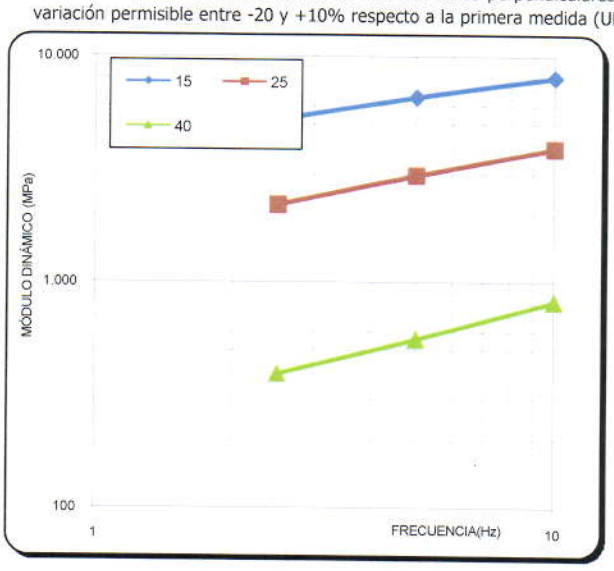
Tipo de mezcla: MD20 - IDU
Localización: PLANTA CENTRASA
Muestra: 3

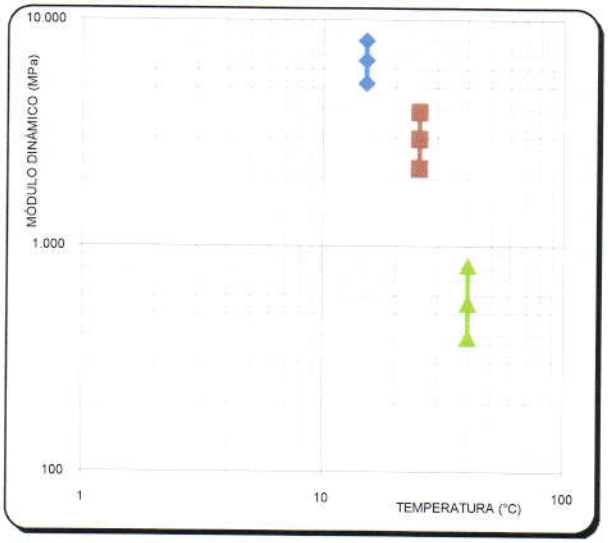
Fecha Recepción: 14-dic-11
Fecha de Ensayo: Reporta resultado
Almacenamiento: Ambiente

Deformación Objetivo 5µm | Tipo de probeta: Marshall | Edad 15 días

BRIQUETA	TEMP. (°C)	FREC. (Hz)	MÓDULO (MPa) Diámetro 1	MÓDULO (MPa) Diámetro 2	Variación %	Módulo Promedio (MPa)	OBSERVACIONES
3	15	10,00	8.081	7.941	1,8	8.011	
3	15	5,00	6.575	6.516	0,9	6.546	
3	15	2,50	5.238	5.142	1,9	5.190	
3	25	10,00	3.912	3.889	0,6	3.901	
3	25	5,00	2.996	2.948	1,6	2.972	
3	25	2,50	2.227	2.185	1,9	2.206	
3	40	10,00	825	800	3,1	813	
3	40	5,00	574	533	7,7	554	
3	40	2,50	403	374	7,8	389	

Nota 1: La prueba se realiza sobre los dos diámetros perpendiculares. El valor del Módulo corresponde al promedio de los dos valores, con una variación permisible entre -20 y +10% respecto a la primera medida (UNE-EN 12697-26).





OBSERVACIONES

La variación entre diámetros perpendiculares NO supera el criterio de la norma EN para una prueba. Se anexan resultados.

EJECUTÓ: LABORATORIO

REVISÓ: DIRECCIÓN TÉCNICA

ADMINISTRADORA DE PROYECTOS CIVILES SAS
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Bogotá, D.C.
527 0376 - 626 1884

Formato ASF-03

ENSAYO DE MÓDULO DE RIGIDEZ - CURVA MAESTRA

INSTRUCTIVO:IE-AF3-01

PROCEDIMIENTO DE ENSAYO: EN 12697:2004 ANEXO C

CÓDIGO ORDEN: 116

PROYECTO: MODULOS CENTRASA

Tipo de mezcla:

Localización: PLANTA CENTRASA

Muestra: 3

Fecha Recepción: 14-dic-11

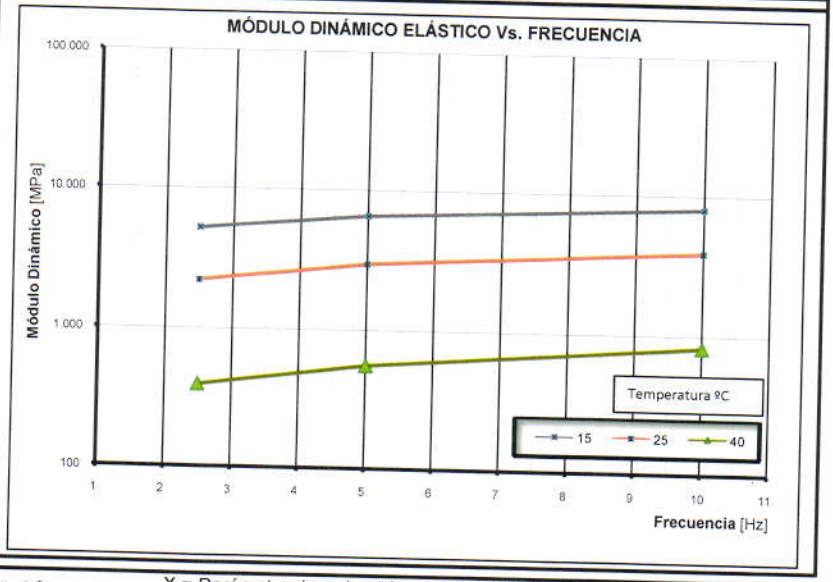
Fecha de Ensayo: *Reporta resultado*

Almacenamiento: Ambiente

Ts = 25 °C

T [°C]	f [Hz]	X	Módulo Dinámico [MPa]
15	10,00	5,24	8.011
	5,00	4,54	6.546
	2,50	3,85	5.190
25	10,00	2,30	3.901
	5,00	1,61	2.972
	2,50	0,92	2.206
40	10,00	-1,75	813
	5,00	-2,44	554
	2,50	-3,13	389

ISOTERMAS



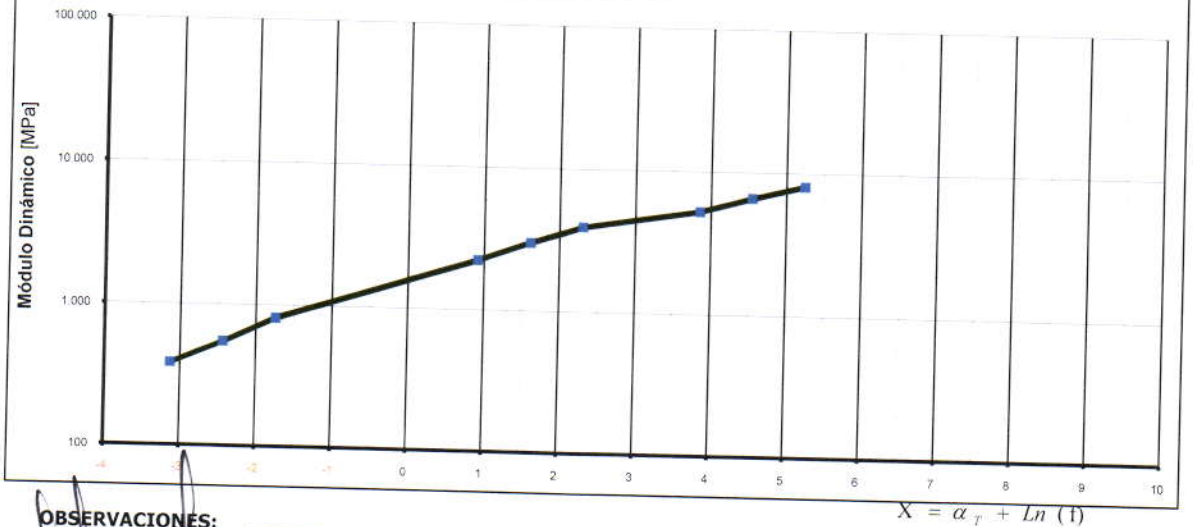
$$X = \alpha_T + Ln\ (f)$$

$$\alpha_T = 2{,}52 \cdot 10^{-4} \cdot \left(\frac{1}{T} - \frac{1}{T_s}\right)$$

α = factor de modificación en función de la temperatura.

X = Parámetro de reducción de la Curva Maestra.
f = frecuencia de la prueba en Hz.
T= Temperatura absoluta de la prueba (T=T°C+273,15).
Ts= Temperatura absoluta de referencia (Ts=Ts°C+273,15).

CURVA MAESTRA



OBSERVACIONES:

EJECUTÓ: LABORATORISTA

REVISÓ: ING. DE LABORATORIO

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-3 F10Hz

Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-03 F10 Hz
Test temperature:	15°C
Specimen diameter:	102 mm
Specimen thickness:	63 mm
Bulk density:	2099 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	33 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

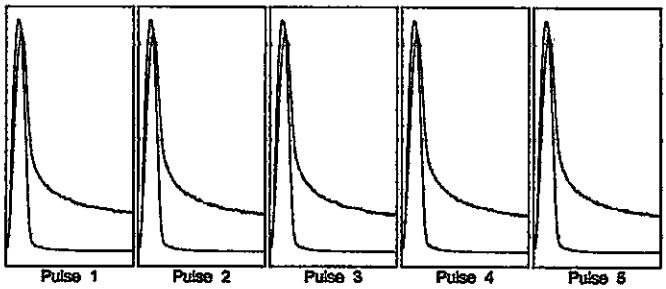
Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
.
.

Date & time of test :	20:Dic:2011 10:19	Client name :	CENTRASA S.A

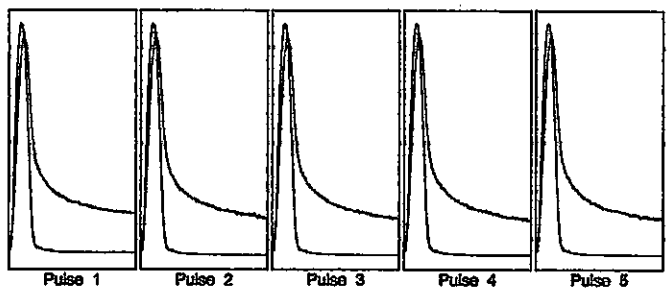
Type and origin of the the bituminous mixture	MD-20
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		4,20	4,21	4,20
Horizontal stress (kPa)		415,9	416,9	416,5
Load-area factor	0,60	0,60	0,61	0,60
Horizontal deformation (µm)	5,0	5,1	5,2	5,1
Load (rise) time (ms):	33	32,0	33,0	32,2
Measured stiffness modulus (MPa)		8019	8136	8081
Adjusted stiffness modulus (MPa)		8030	8123	8081

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		4,03	4,07	4,04
Horizontal stress (kPa)		399,3	403,4	400,4
Load-area factor	0,60	0,59	0,61	0,60
Horizontal deformation (µm)	5,0	5,0	5,0	5,0
Load (rise) time (ms):	33	32,0	33,0	32,6
Measured stiffness modulus (MPa)		7883	7974	7931
Adjusted stiffness modulus (MPa)		7917	8001	7941

Mean results of the two tests

Load (rise) time (ms):	:	32,4
Horizontal deformation (µm)	:	5,1
Horizontal deformation (%)	:	0,0050
Measured stiffness modulus (MPa)	:	7996
Adjusted stiffness modulus (MPa)	:	8011

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (2)

Person responsible for this test report	Signed
LUTHER HERRERA	Date of issue of report: 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-3 F5Hz

Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-03 F5 Hz
Test temperature:	15°C
Specimen diameter:	102 mm
Specimen thickness:	63 mm
Bulk density:	2099 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	63 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Address of testing laboratory

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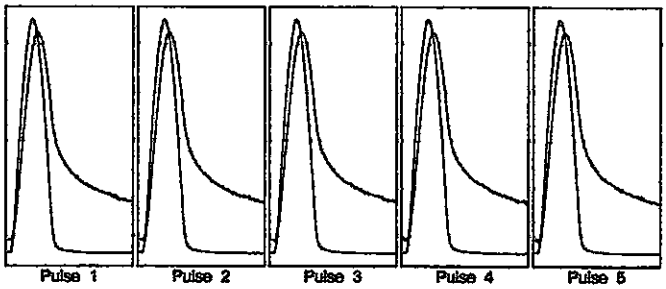
contacto@apcltda.net
.
.

Date & time of test :	20:Dic:2011 10:25	Client name :	CENTRASA S.A

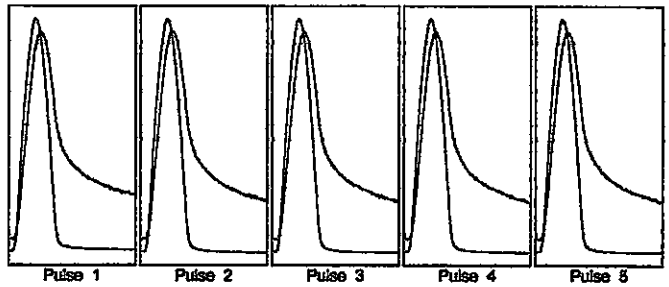
Type and origin of the the bituminous mixture	MD-20
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		3,33	3,33	3,33
Horizontal stress (kPa)		329,4	329,9	329,6
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,0	5,0	5,0
Load (rise) time (ms):	63	62,0	62,0	62,0
Measured stiffness modulus (MPa)		6515	6579	6544
Adjusted stiffness modulus (MPa)		6509	6620	6575

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		3,34	3,37	3,35
Horizontal stress (kPa)		330,9	334,3	331,6
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,0	5,1	5,1
Load (rise) time (ms):	63	63,0	65,0	63,4
Measured stiffness modulus (MPa)		6458	6514	6469
Adjusted stiffness modulus (MPa)		6458	6552	6516

Mean results of the two tests

Load (rise) time (ms):	:	62,7
Horizontal deformation (µm)	:	5,0
Horizontal deformation (%)	:	0,0049
Measured stiffness modulus (MPa)	:	6515
Adjusted stiffness modulus (MPa)	:	6546

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (0,9)

Person responsible for this test report	Signed
LUTHER HERRERA	Date of issue of report: 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-3 F2.5Hz

Address of testing laboratory

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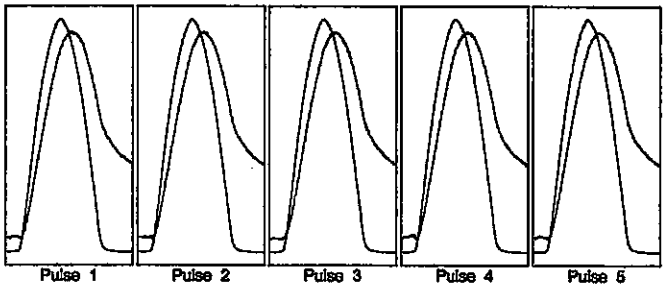
Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-03 F2.5 Hz
Test temperature:	15°C
Specimen diameter:	102 mm
Specimen thickness:	63 mm
Bulk density:	2099 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	124 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 10:29	Client name :	CENTRASA S.A

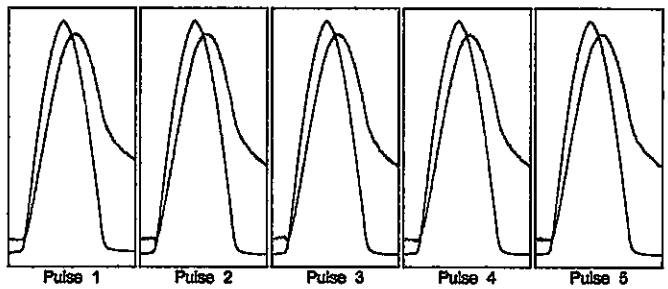
Type and origin of the the bituminous mixture	MD-20
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		2,66	2,67	2,66
Horizontal stress (kPa)		263,2	264,4	263,5
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,0	5,0	5,0
Load (rise) time (ms):	124	123,0	125,0	124,0
Measured stiffness modulus (MPa)		5187	5259	5212
Adjusted stiffness modulus (MPa)		5215	5298	5238

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		2,63	2,67	2,64
Horizontal stress (kPa)		280,1	284,1	281,4
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,0	5,2	5,1
Load (rise) time (ms):	124	122,0	125,0	124,2
Measured stiffness modulus (MPa)		5088	5162	5119
Adjusted stiffness modulus (MPa)		5118	5178	5142

Mean results of the two tests

Load (rise) time (ms):	:	124,1
Horizontal deformation (µm)	:	5,0
Horizontal deformation (%)	:	0,0049
Measured stiffness modulus (MPa)	:	5166
Adjusted stiffness modulus (MPa)	:	5190

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (2)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-3 F10 Hz

Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
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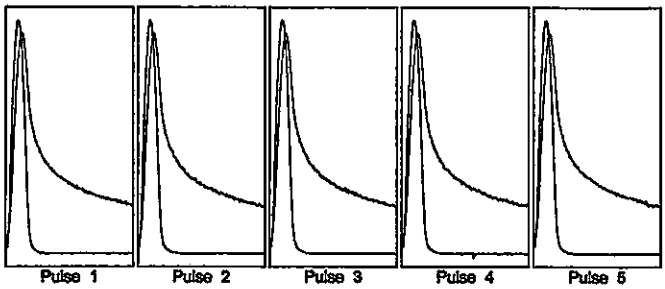
Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-05 F10 Hz
Test temperature:	25°C
Specimen diameter:	102 mm
Specimen thickness:	63 mm
Bulk density:	2099 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	33 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 16:00	Client name :	CENTRASA S.A

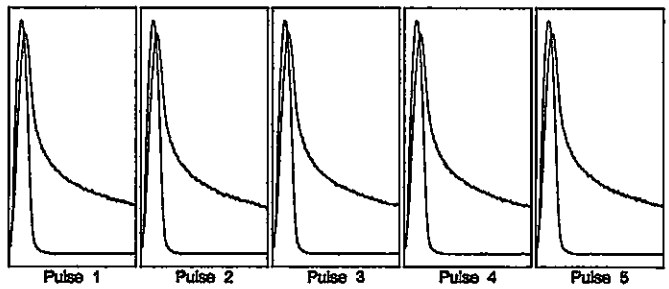
Type and origin of the the bituminous mixture	MD-20
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		2,01	2,01	2,01
Horizontal stress (kPa)		198,6	199,3	199,1
Load-area factor	0,60	0,59	0,61	0,60
Horizontal deformation (µm)	5,0	5,0	5,1	5,1
Load (rise) time (ms):	33	32,0	33,0	32,6
Measured stiffness modulus (MPa)		3876	3939	3914
Adjusted stiffness modulus (MPa)		3886	3953	3912

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,99	2,00	2,00
Horizontal stress (kPa)		197,2	198,3	197,7
Load-area factor	0,60	0,60	0,61	0,60
Horizontal deformation (µm)	5,0	5,0	5,1	5,1
Load (rise) time (ms):	33	32,0	34,0	32,8
Measured stiffness modulus (MPa)		3887	3902	3880
Adjusted stiffness modulus (MPa)		3888	3923	3889

Mean results of the two tests

Load (rise) time (ms):	:	32,7
Horizontal deformation (µm)	:	5,1
Horizontal deformation (%)	:	0,0050
Measured stiffness modulus (MPa)	:	3897
Adjusted stiffness modulus (MPa)	:	3901

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (0,6)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-3 F5 Hz

Address of testing laboratory

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Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
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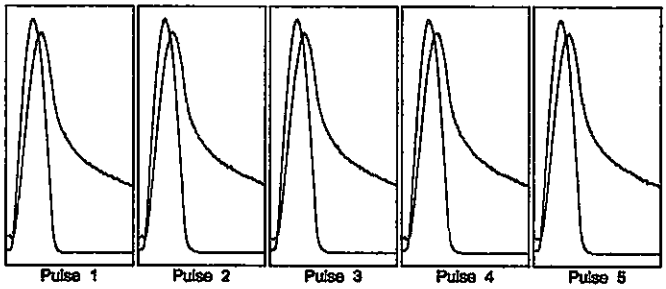
.

Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-03 F5 Hz
Test temperature:	25°C
Specimen diameter:	102 mm
Specimen thickness:	63 mm
Bulk density:	2099 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	63 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	20:Dic:2011 16:05	Client name :	CENTRASA S.A

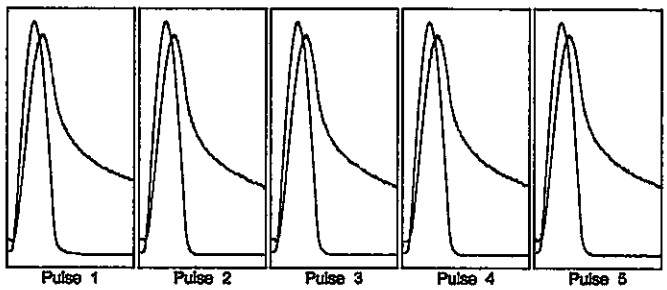
Type and origin of the the bituminous mixture	MD-20
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,53	1,56	1,55
Horizontal stress (kPa)		151,6	154,1	153,4
Load-area factor	0,60	0,60	0,61	0,61
Horizontal deformation (µm)	5,0	5,0	5,2	5,1
Load (rise) time (ms):	63	62,0	64,0	62,6
Measured stiffness modulus (MPa)		2952	3018	2982
Adjusted stiffness modulus (MPa)		2968	3032	2996

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,53	1,56	1,54
Horizontal stress (kPa)		151,3	154,4	152,7
Load-area factor	0,60	0,59	0,61	0,60
Horizontal deformation (µm)	5,0	5,1	5,3	5,2
Load (rise) time (ms):	63	62,0	64,0	63,4
Measured stiffness modulus (MPa)		2908	2960	2943
Adjusted stiffness modulus (MPa)		2899	2967	2948

Mean results of the two tests

Load (rise) time (ms):	:	63,0
Horizontal deformation (µm)	:	5,1
Horizontal deformation (%)	:	0,0050
Measured stiffness modulus (MPa)	:	2963
Adjusted stiffness modulus (MPa)	:	2972

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (2)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-3 F2.5Hz

Date of print-out:	20:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-03 F2.5 Hz
Test temperature:	25°C
Specimen diameter:	102 mm
Specimen thickness:	63 mm
Bulk density:	2099 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	124 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

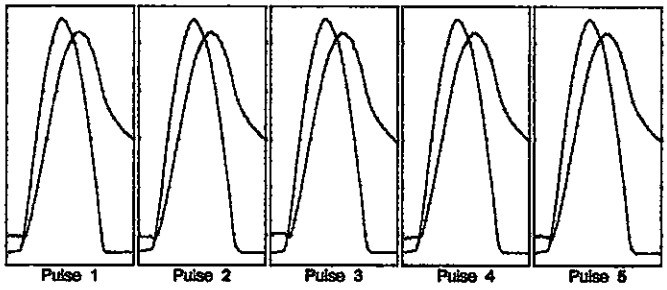
Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net

Date & time of test :	20:Dic:2011 16:09	Client name :	CENTRASA S.A

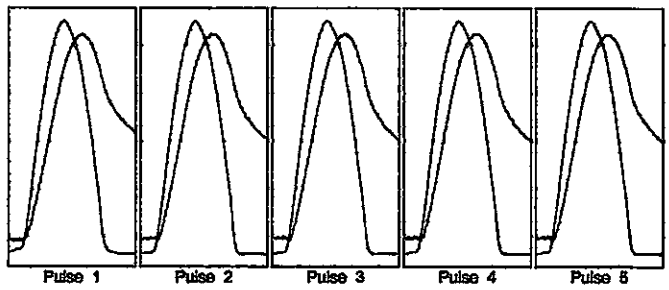
Type and origin of the the bituminous mixture	MD-20
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,14	1,17	1,16
Horizontal stress (kPa)		113,1	116,3	115,1
Load-area factor	0,60	0,59	0,61	0,60
Horizontal deformation (µm)	5,0	5,1	5,2	5,1
Load (rise) time (ms):	124	123,0	128,0	124,8
Measured stiffness modulus (MPa)		2212	2245	2228
Adjusted stiffness modulus (MPa)		2217	2251	2227

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		1,17	1,20	1,18
Horizontal stress (kPa)		116,8	118,8	116,8
Load-area factor	0,60	0,60	0,62	0,61
Horizontal deformation (µm)	5,0	5,2	5,6	5,3
Load (rise) time (ms):	124	123,0	126,0	124,8
Measured stiffness modulus (MPa)		2114	2207	2160
Adjusted stiffness modulus (MPa)		2121	2207	2165

Mean results of the two tests

Load (rise) time (ms):	:	124,8
Horizontal deformation (µm)	:	5,2
Horizontal deformation (%)	:	0,0051
Measured stiffness modulus (MPa)	:	2203
Adjusted stiffness modulus (MPa)	:	2206

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (2)

Person responsible for this test report	Signed
LUTHER HERRERA	Date of issue of report: 20:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-3 F10Hz

Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
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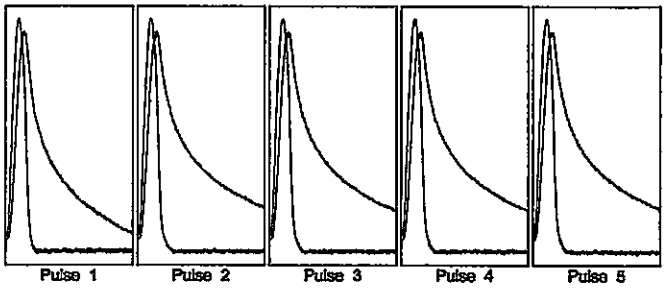
Date of print-out:	21:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-03 F10 Hz
Test temperature:	40°C
Specimen diameter:	102 mm
Specimen thickness:	63 mm
Bulk density:	2099 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	33 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	21:Dic:2011 08:57	Client name :	CENTRASA S.A

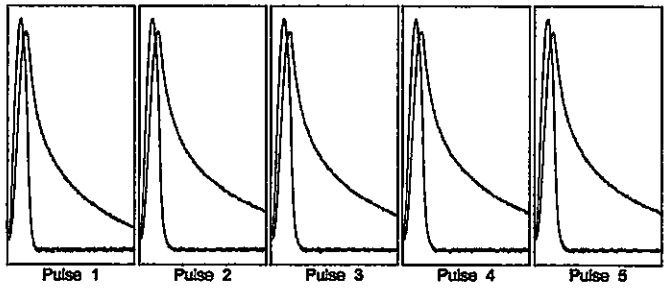
Type and origin of the the bituminous mixture	MD-20
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,46	0,48	0,47
Horizontal stress (kPa)		45,7	47,5	46,8
Load-area factor	0,60	0,59	0,60	0,60
Horizontal deformation (µm)	5,0	5,0	5,9	5,7
Load (rise) time (ms):	33	33,0	38,0	35,2
Measured stiffness modulus (MPa)		799	913	826
Adjusted stiffness modulus (MPa)		797	912	825

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,47	0,48	0,48
Horizontal stress (kPa)		46,1	47,8	47,2
Load-area factor	0,60	0,57	0,62	0,60
Horizontal deformation (µm)	5,0	5,3	6,1	5,9
Load (rise) time (ms):	33	32,0	38,0	34,0
Measured stiffness modulus (MPa)		778	881	801
Adjusted stiffness modulus (MPa)		777	868	800

Mean results of the two tests

Load (rise) time (ms):	:	34,6
Horizontal deformation (µm)	:	5,8
Horizontal deformation (%)	:	0,0056
Measured stiffness modulus (MPa)	:	814
Adjusted stiffness modulus (MPa)	:	813

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (3)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 21:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-3 F5Hz

Address of testing laboratory

APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
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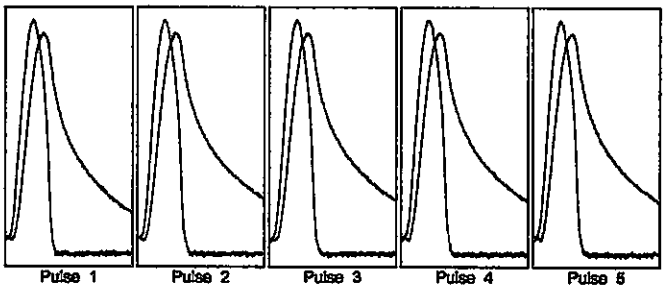
.

Date of print-out:	21:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-03 F5 Hz
Test temperature:	40°C
Specimen diameter:	102 mm
Specimen thickness:	63 mm
Bulk density:	2099 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	63 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	21:Dic:2011 09:02	Client name :	CENTRASA S.A

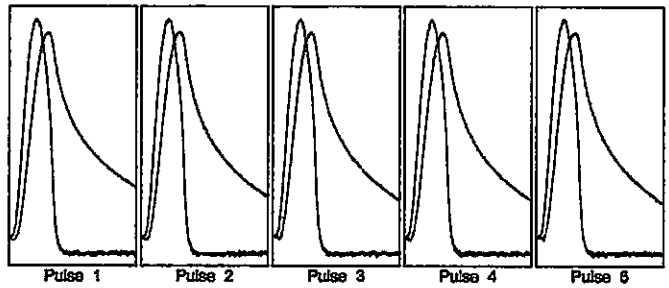
Type and origin of the the bituminous mixture	MD-20
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20ºC
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,33	0,34	0,34
Horizontal stress (kPa)		32,4	33,9	33,5
Load-area factor	0,60	0,59	0,61	0,60
Horizontal deformation (µm)	5,0	5,1	6,0	5,8
Load (rise) time (ms):	63	58,0	68,0	63,4
Measured stiffness modulus (MPa)		557	626	575
Adjusted stiffness modulus (MPa)		556	626	574

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,34	0,35	0,35
Horizontal stress (kPa)		34,2	34,9	34,7
Load-area factor	0,60	0,60	0,62	0,61
Horizontal deformation (µm)	5,0	6,3	6,8	6,5
Load (rise) time (ms):	63	62,0	66,0	64,2
Measured stiffness modulus (MPa)		510	542	532
Adjusted stiffness modulus (MPa)		509	543	533

Mean results of the two tests

Load (rise) time (ms):	:	63,8
Horizontal deformation (µm)	:	6,1
Horizontal deformation (%)	:	0,0060
Measured stiffness modulus (MPa)	:	554
Adjusted stiffness modulus (MPa)	:	554

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (7)

Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 21:12:2011

Indirect tensile stiffness modulus test report.

(EN 12697-26:2004(Annex C): (Equipment - NU-14)-HYD25)
Serial No. of this test report: LAB116-3F2.5Hz

Address of testing laboratory

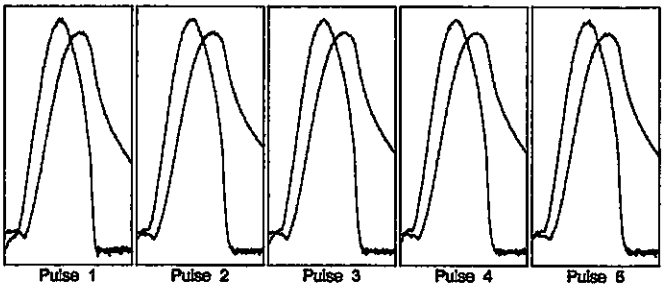
APC LTDA.
Calle 154 n 17 - 78
Tel (57 1) 5 27 0241 - 5 27 0236
Bogotá D.C., Colombia
contacto@apcltda.net
.
.

Date of print-out:	21:12:2011
Test carried out by:	LUTHER HERRERA
Specimen reference:	LAB116-03 F2.5 Hz
Test temperature:	40°C
Specimen diameter:	102 mm
Specimen thickness:	63 mm
Bulk density:	2099 (kg/m³)
Poisson's ratio:	0,35
Target rise-time:	124 ms
Target horizontal deformation:	5 µm
Number of conditioning pulses:	20
Transducer scan rate:	1000 Hz

Date & time of test :	21:Dic:2011 09:07	Client name :	CENTRASA S.A

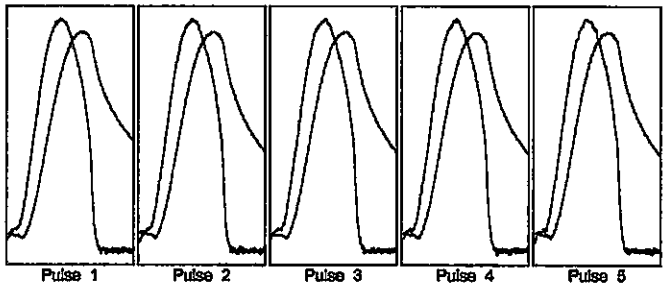
Type and origin of the the bituminous mixture	MD-20
Method of manufacture of the bituminous mixture	MARSHALL
Method of compaction	IMPACTO
Specimen storage details	Ambiente 20°C
Bulk density determination method:	I.N.V. E-733/07

Test along 1st diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,23	0,26	0,25
Horizontal stress (kPa)		22,7	25,8	26,1
Load-area factor	0.60	0,59	0,63	0,61
Horizontal deformation (µm)	5,0	5,3	6,6	6,2
Load (rise) time (ms):	124	122,0	132,0	126,6
Measured stiffness modulus (MPa)		389	430	402
Adjusted stiffness modulus (MPa)		391	429	403

Test along 2nd diameter



Results	Target	Minimum	Maximum	Mean
Vertical force (kN)		0,25	0,25	0,25
Horizontal stress (kPa)		24,4	25,2	24,7
Load-area factor	0.60	0,58	0,62	0,60
Horizontal deformation (µm)	5,0	6,3	7,0	6,6
Load (rise) time (ms):	124	117,0	126,0	122,6
Measured stiffness modulus (MPa)		349	382	374
Adjusted stiffness modulus (MPa)		348	384	374

Mean results of the two tests

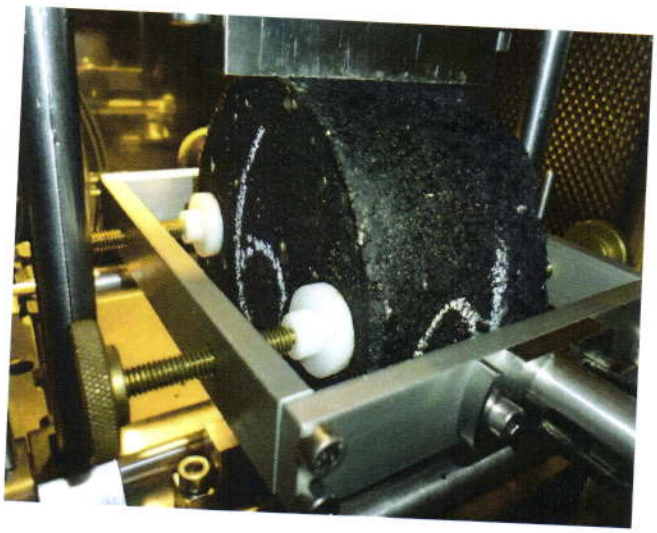
Load (rise) time (ms):	:	124,1
Horizontal deformation (µm)	:	6,4
Horizontal deformation (%)	:	0,0063
Measured stiffness modulus (MPa)	:	388
Adjusted stiffness modulus (MPa)	:	389

Percentage difference between 1st and 2nd mean adjusted stiffness moduli = (7)

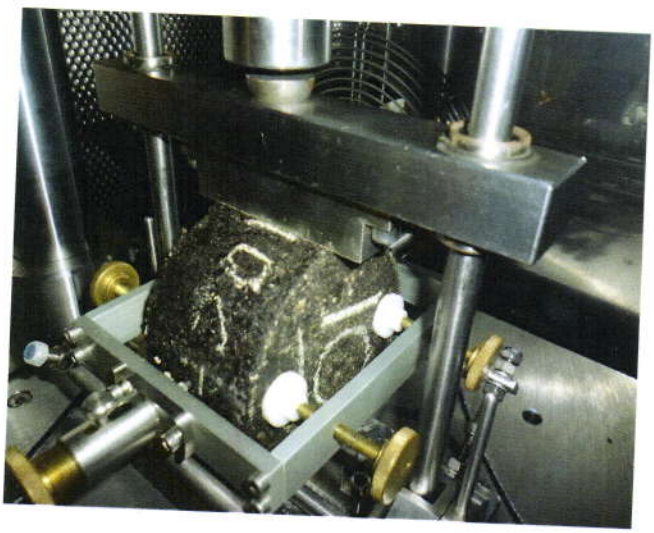
Person responsible for this test report LUTHER HERRERA	Signed Date of issue of report 21:12:2011

ANEXO 2.
REGISTRO FOTOGRAFICO

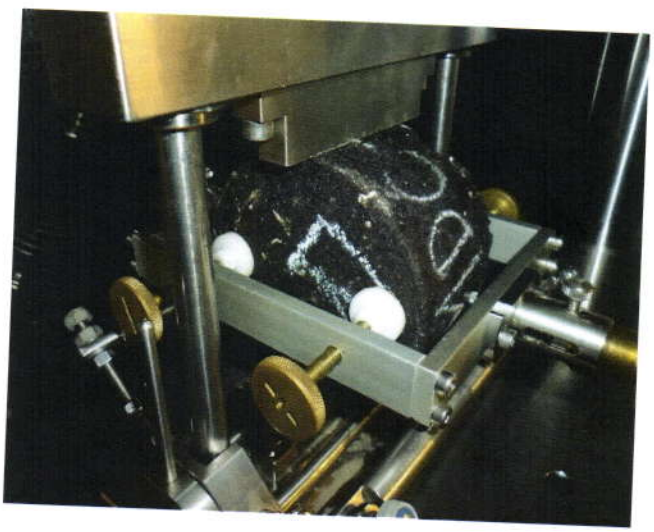
FOTOGRAFÍA No.1 Muestras durante el proceso de climatización



FOTOGRAFÍA No. 2 - Briqueta No.6 durante el ensayo de módulo



FOTOGRAFÍA No. 3 - Briqueta No.10 durante el ensayo de módulo



FOTOGRAFÍA No. 4 – Briqueta No. 5 durante el ensayo de módulo

ANEXO 3.
RESULTADOS DENSIDADES MEZCLA ASFALTICA MDC-1 ,MDC-2, MD-12 Y MD-20
MEDIDAS Y REGISTRO.

ADMINISTRADORA DE PROYECTOS CIVILES SAS

Calle 154 n 17 78
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Bogotá, D.C.
527 02 41 - 527 0376

GRAVEDAD ESPECÍFICA BULK Y DENSIDAD DE MEZCLAS ASFÁLTICAS COMPACTADAS - INV E 733

Formato ASF-05 TD

TOMA DE DATOS DE Ddensidades

INSTRUCTIVO DE ENSAYO:IE-ASF05

I.N.V. E – 733 – 07

Código de Orden	**LAB116**	**Descripción / Tipo de mezcla:**	MDC-1, MDC-2, MD-12, MD-20	**Método de compactación:**	Marshall	**Fecha de Fabricación:**	N/D

Probeta No	Masa del especimen seco al aire A g	Masa en el aire saturado y superficie seca B g	Masa del espécimen en agua C g	Temperatura Agua °C	Factor de Corrección K	Gravedad Especifica Bulk	Gravedad Especifica Bulk , a 25° C	Densidad kg/m³	Agua absorbida por volumen %	Chequeo	Observaciones
5	1.106	1106	603	21	1,000950	**2,199**	**2,198**	**2.192**	**0,0%**	ok	MDC-1
3	1.105	1104	615	21	1,000950	**2,260**	**2,259**	**2.252**	**0,2%**	ok	MDC-2
10	1.109	1110	592	21	1,000950	**2,141**	**2,140**	**2.134**	**0,2%**	ok	MDC-2
6	1.103	1104	613	21	1,000950	**2,246**	**2,246**	**2.239**	**0,2%**	ok	MD-12
3	1.131	1132	595	21	1,000950	**2,106**	**2,106**	**2.099**	**0,2%**	ok	MD-20

OBSERVACIONES _____

EJECUTO: LABORATORISTA

REVISÓ: DIRECCIÓN TÉCNICA

ANEXO 4.
NOTAS TECNICAS

Condiciones de Ensayo y Uso de los resultados:

Gillespie et al. encontró que para camiones la frecuencia de carga es de 4,6 Hz para una velocidad de 58 km/h y de 6,5 Hz para una velocidad de 82 km/h.

El método Shell (Huang, pg 302) propone que para velocidades de 50 a 60 km/h el tiempo de aplicación de la carga es de 0,02 s y la frecuencia de carga de 8 Hz.

El valor de módulo empleado para el diseño en el Reino Unido es el de una frecuencia de 5 Hz.

Ahmed (1995) propone la siguiente ecuación para determinar la temperatura de la mezcla a una profundidad de 2 cm:

$$MMPT(°C) = MMAT\ (°C) + 5°C$$

Donde:

MMPT(°C) : Temperatura media mensual del pavimento
MMAT (°C) + Temperatura media mensual del aire

Según Shell, la temperatura de la mezcla corresponde a la siguiente fórmula:

$$Tmezcla = 1{,}184(Tw\text{-}maat + 0{,}04848)$$

Donde:

Tw-maat (°C): Temperatura media mensual del aire ponderada.

RESULTADOS

Valores característicos de módulos dinámicos de mezclas asfálticas.

Temperatura		Frecuencia								
		1Hz			4Hz			16Hz		
		Rango		Media	Rango		Media	Rango		Media
°F	°C	MPa		MPa	MPa		MPa	MPa		MPa
40	4.4	4137	12411	**8274**	6205	18616	**12411**	6895	20684	**13790**
70	21.1	1379	4137	**1724**	2758	6205	**4482**	3447	7584	**5516**
100	37.8	345	1034	**689**	483	1517	**1000**	689	2206	**1448**

Fuente: Huang, pg 309

ANEXO 5.

Norma técnica Métodos de ensayo para mezclas bituminosas en caliente. Parte 26: Rigidez (UNE-EN 12697-26, Anexo c)