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(54) **PAVEMENT STRUCTURE**

(57) The aim - by using asphalt pavement design model ViaStructura to design road pavement structure and technological process for its application. The model of pavement structural layers and partial layers shall take into account the total effect of the groups of vehicle axle loads and air temperature. Asphalt pavement structure, consisting of asphalt wearing layer, asphalt binder layer, asphalt base layer and unbound mineral material layers, is distinguished by the fact that thicknesses of the layers were optimized based on mechanical properties of materials and vehicle axle load of, for example, 7 million

ESA, and pavement structure durability was checked by an individual-design model ViaStructura taking into account temperature and load spectra effects. The structure of asphalt pavement consists of:

Asphalt wearing layer (SMA 11 S) - 2,5-4,0 cm,
Asphalt binder layer (AC 16 AS) - 4,0-8,0 cm,
Asphalt base layer (AC 22 PS) - 7,0-15,0 cm,
Crushed-stone base layer (SPS fr. 0/45) - 15,0-20,0 cm,
Frost resistant layer (AŠAS) - 40,0-70,0 cm,
Subgrade (ŽS) soils of average (F2) frost-susceptibility $EV_2 \geq 70$ MPa.

DK 10-4

	3,5 cm	SMA 11 S
	5,0 cm	AC 16 AS
	8,0 cm	AC 22 PS
	15,0 cm	SPS fr. 0/45
	40,0 cm	AŠAS
	-	ŽS (F2)

FIG. 1

Description

TECHNICAL FIELD

5 **[0001]** The below-described invention falls under class E01 *Construction of Roads, Railways, or Bridges*, subclass E01C 1/00 *Design or Layout of Roads* (according to the *International Patent Classification IPC* of the *World Intellectual Property Organization WIPO*). Specifically, this invention improves asphalt pavement structure, which is applied under conditions of dynamic transport loading and changing climate, and to which enhanced requirements of durability are set.

10 BACKGROUND ART

[0002] The generally known conventional pavement structures are selected by the catalogues, such as:

- FGSV. Richtlinien für die Standardisierung des Oberbaues von Verkehrsflächen RStO 12, 2012;
- 15 - Lietuvos automobilių kelių direkcija. Automobilių kelių standartizuotų dangų konstrukcijų projektavimo taisyklės KPT SDK 19, 2019 (Lithuanian Road Administration. Design Rules for the Standard Pavement Structures of Roads);
- LVCELI. Cēla segu tipveida konstrukciju katalogs, 2010;
- 20 - GDDKIA. KATALOG Typowych konstrukcji nawierzchni podatnych i półsztywnych, 2012;
- MDOSI. Navrhování vozovek pozemních komunikací technické podmínky TP 170, 2010.

[0003] The catalogues suggest selecting pavement structure according to the equivalent standard axle load - ESAL, which assesses the effect of heavy-weight vehicles but takes no consideration of a spectrum of heavy axle loads when they are distributed into 12 load groups at intervals of 2 tonnes from 0 to 22 tonnes. When using catalogues for selecting pavement structure the effect of air temperature change on asphalt layers and on the whole pavement structure during its design life has not been assessed. This means that irrespective of local environmental conditions of individual country or region the same thickness and layer composition of pavement structures are applied. The catalogues usually suggest selecting pavement structure of class DK 10 as a standard pavement structure, the ESAL of which varies in a wide range from 3 to 10 million during pavement design life.

[0004] In accordance with KPT SDK 19 (*LAKD. Automobilių kelių standartizuotų dangų konstrukcijų projektavimo taisyklės* (LRA. *Design Rules for the Standard Pavement Structures of Roads*) and RStO 12 (FGSV. *Richtlinien für die Standardisierung des Oberbaues von Verkehrsflächen RStO 12, 2012*) the most commonly applied pavement structure of class DK 10 (where design load A is >3-10 million ESAL) consists of: 12 cm thick asphalt wearing and asphalt binder layer, 10 cm thick asphalt base layer, 20-40 cm thick unbound aggregate mixture base layer and frost resistant base layer, thickness of which is selected depending on a frost depth, that are laid on a compacted subgrade. An alternative class according to the Latvian catalogue (LVCELI. *Cēla segu tipveida konstrukciju katalogs, 2010*) is class II (where A is >3-10 million ESAL), of which pavement structure consists of: 4 cm thick asphalt wearing layer, 4 cm thick asphalt binder layer, 6 cm thick asphalt base layer, 25-38 cm of unbound aggregate mixture base layer and 31-46 cm of frost resistant layer that are laid on a compacted subgrade. An alternative class according to the Polish catalogue (GDDKIA.

KATALOG Typowych konstrukcji nawierzchni podatnych i półsztywnych, 2012) is class KR4 (where A is >2,5-7,3 million ESAL), of which pavement structure consists of: 4 cm thick asphalt wearing layer, 6 cm thick asphalt binder layer, 10 cm thick asphalt base layer and 20-22 cm of unbound aggregate mixture base layer that are laid on compacted frost-insensitive subgrade. An alternative class according to the Czech catalogue (MDOSI. *Navrhování vozovek pozemních komunikací technické podmínky TP 170, 2010*) is II (where A is >3,7-10 million ESAL) and pavement structure consists of: 4 cm thick asphalt wearing layer, 7 cm thick asphalt binder layer, 9 cm thick asphalt base layer and 20 cm of unbound aggregate mixture base layer that are laid on a compacted subgrade. However, all those conventional structures are designed for a wide range of load groups and may be ineffective from the economic and environmental point of view, for example, when in a road section a design load A is 4 million ESAL and pavement structure must comply with 10 million ESA, which has a higher than 50% reserve of the bearing capacity than needed. Moreover, conventional pavement structures are designed by using standard road building materials, the properties of which are defined in normative construction technical documents, for example, *Automobilių kelių asfalto mišinų techninių reikalavimų aprašas* (Technical Requirements for Road Asphalt Mixtures) TRA ASFAL TAS 08 (2008). This limits the use of new, innovative, stronger road building materials and optimization of layer thicknesses depending on real loads and material properties. It is also known that the use of conventional asphalt mixtures does not take into account resistance of pavement structures to fatigue and permanent deformations, thus, subjecting road pavements to more rapid degradation.

[0005] Conventional pavement structures are in most cases determined by empirical or semi-empirical methods, which

are based on field observations of pavement performance under local environmental and loading conditions. The first data about pavement structure performance under natural conditions were collected as far back as 1960 in the framework of AASHO (American Association of State Highway Officials) Highway Research Project (AASHO Road Test: History and Description of Project. 1961. Publication 816, National Research Council, Washington; AASHO Interim Guide for Design of Pavement Structure. 1972.). Since then many data have been collected during implementation of long-term road researches (Long-Term Pavement Performance Program as part of the Strategic Highway Research Program) and after construction of test road sections in Minnesota (Minnesota Road Research Project, Work Plan for Research Objectives, Report No. 90-03, Minnesota Department of Transportation, 1990) and in Connecticut, National Centre for Asphalt Technology at Auburn University (Brown et. al. 2002. NCAT Test Track Design, Construction and Performance, National Centre for Asphalt Technology). From 2007 in Lithuania Test Road (Laurinavicius et al. 2007. Research of Experimental Road Pavement Structures in Lithuania). With the use of laboratory-determined mechanical properties of materials and pavement performance models, developed from experimental test sections, the mechanistic-empirical design models were developed (MEPDG. 2004. Mechanistic-Empirical Pavement Design Guide. Project 1-37A. National Cooperative Highway Research Program; SAPDM. 2015. South African Pavement Design Method; KPDG. 2007. Report of Korean Pavement Design Guide Project. Draft Final Report KPRP- G-07; ViaStructura. 2018. Development of Asphalt Pavement Design Model and its Application Software) enabling to assess pavement performance from the point of view of fatigue and permanent deformations. As technology progresses, building materials of new generation are being created, and with a changing climate there is an inevitable need for economically-rational and functionally-effective transport infrastructure, which starts from using innovative design models. Functionality of a design pavement structure can only be ensured by accurate implementation, therefore an individual project of pavement structure is inseparable from the description of technological process.

SUMMARY

[0006] This invention creates road pavement structures by using individual-design model ViaStructura, by assessing mechanical properties of materials and calculating optimum layer thicknesses according to the air temperature (varying from -20°C to +50°C) and traffic loading (varying from 2 t to 22 t) during pavement design life. The invention presents individually modelled durable road pavement structures, illustrated by examples.

[0007] The aim of invention - by using asphalt pavement design model ViaStructura to design road pavement structure and technological process for its application. The model of pavement structural layers and partial layers shall take into account the total effect of the groups of vehicle axle loads and air temperature.

[0008] The aim is achieved in a way that the road pavement structure of class DK 10 is modelled by a design model ViaStructura where thicknesses of pavement structure and its structural layers are determined according to the real design load A and its distribution into load groups and the predicted change in air temperature during pavement design life. For modelling purposes the following assumptions were made:

- A new national road is being designed;
- Maximum freeze depth - 140 cm;
- Distribution of traffic flow axle loads is given in Table 1;
- Distribution of asphalt pavement surface temperature is given in Table 2.

Table 1. Distribution of traffic flow axle loads

AK1	AK2	AK3	AK4	AK5	AK6	AK7	AK8	AK9	AK10	AK11
2 t	4 t	6 t	8 t	10 t	12 t	14 t	16 t	18 t	20 t	22 t
(0:2]	(2:4]	(4:6]	(6:8]	(8:10]	(10:12]	(12:14]	(14:16]	(16:18]	(18:20]	(20:n]
20,2899	29,3130	19,2824	16,0829	6,5658	4,0247	2,4484	1,1345	0,4592	0,2205	0,1787

Table 2. Distribution of asphalt pavement surface temperature

T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
-17,5°C	-12,5 C	-7,5°C	-2,5°C	2,5°C	7,5°C	12,5°C	17,5°C	22,5°C	27,5°C	32,5°C	37,5°C	42,5°C	47,5°C
(-t;-15)	(-15;-10]	(-10;-5]	(-5;0]	(0;5]	(5;10]	(10;15]	(15;20]	(20;25]	(25;30]	(30;35]	(35;40]	(40;45]	(45;t)
0,380	1,610	4,995	13,563	19,629	14,359	11,446	12,484	10,031	5,965	3,303	1,587	0,531	0,117

[0009] The aim is achieved by presenting three pavement structures for different loading levels (min. - 4 million ESAL; avg. - 7 million ESAL; max. - 10 million ESAL) where pavement structural layers and their thicknesses are as follows:

Asphalt wearing layer (SMA 11 S) - 2,5-4,0 cm,
 Asphalt binder layer (AC 16 AS) - 5,0-8,0 cm,
 Asphalt base layer (AC 22 PS) - 8,0-10,0 cm,
 Crushed-stone base layer (SPS fr. 0/45) - 15,0-20,0 cm,
 Frost resistant layer (ASAS) - 40,0-70,0 cm,
 Subgrade (ŽS) soils of average (F2) frost-susceptibility $EV_2 \geq 70$ MPa.

[0010] Optimum composition of asphalt pavement structure and layer thicknesses were determined by a specialized asphalt pavement design model ViaStructura and based on experimental research results.

DESCRIPTION OF DRAWINGS

[0011]

FIG. 1. Shows pavement structure DK 10-4;
 FIG. 2. Shows pavement structure DK 10-7;
 FIG. 3. Shows pavement structure DK 10-10.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Example No. 1: an individual design of pavement structure

[0012] Asphalt pavement structure DK 10-4 is designed for the minimum ESAL of 4 million. Composition and type of materials, thickness of structural layers are given in FIG. 1.

Example No. 2: an individual design of pavement structure

[0013] Asphalt pavement structure DK 10-7 are designed for the minimum ESAL of 7 million. Composition and type of materials, thickness of structural layers are given in FIG. 2.

Example No. 3: an individual design of pavement structure

[0014] Asphalt pavement structure DK 10-10 are designed for the minimum ESAL of 10 million. Composition and type of materials, thickness of structural layers are given in FIG. 3.

[0015] Physical and mechanical properties of materials, used in pavement structural layers, and technological conditions for their application are given in Table 3.

Table 3. Properties of materials used in pavement structural layers

Pavement structural layer	Thickness, cm			Material	Properties
	DK 10-4	DK 10-7	DK 10-10		
Asphalt wearing layer	3,5	4,0	4,0	SMA 11 S (PMB 45/80-60 or PMB 25/55-60)	$E_{(T20C)} > 6480 \text{ MPa}^1$ $RD_{AIR(T50C)} < 1,5 \text{ mm}^2$
Asphalt binder layer	5,0	7,0	8,0	AC 16 AS (PMB 45/80-60 or PMB 25/55-60)	$E_{(T20C)} > 9680 \text{ MPa}^1$
Asphalt base layer (AC)	8,0	8,0	10,0	AC 22 PS (50/70)	$E_{(T20C)} > 5580 \text{ MPa}^1$
Crushed-stone base layer (SPS)	20,0	20,0	20,0	Crushed-stone (fr. 0/32-0/56)	$EV_2 \geq 150 \text{ MPa}^3$, $D_{Pr} \geq 103\%$
Frost resistant layer (ASAS)	40,0	40,0	40,0	Unbound aggregate mixtures (fr. 0/16-0/63) or soils ⁴	$EV_2 \geq 100 \text{ MPa}^3$, $k \geq 2 \times 10^{-5} \text{ m/s}$

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(continued)

Pavement structural layer	Thickness, cm			Material	Properties
	DK 10-4	DK 10-7	DK 10-10		
Compacted subgrade (ŽS)	>30,0	>30,0	>30,0	Frost-susceptibility class of soil F2	$E_{V2} > 70 \text{ MPa}^3$
Limit state	0,98	0,88	0,94	AC	Fatigue
	0,23	0,05	0,06	SPS	Permanent deformation
	0,20	0,07	0,07	AŠAS	
	0,07	0,04	0,04	ŽS	
Remarks: 1 - Hot asphalt mixture stiffness was determined at 20°C in accordance with the standard LST EN 12697-26. 2 - Hot asphalt mixture rutting resistance, characterized by rut depth and wheel tracking slope, was determined by a small-size device (Procedure B in air) at 50°C in accordance with the standard LST EN 12697-22. 3 - The modulus of deformation, determined by the second loading cycle in accordance with the standard LST 1360-5, shall be ensured independently of environmental and hydrogeological conditions. 4 - poorly-graded gravel ŽB, well-graded gravel ŽG, medium-graded gravel ŽP; poorly-graded sand SB, well-graded sand SG, medium-graded sand SP in accordance with the standard LST 1331.					

[0016] The created and accurately laid (according to the data of Table 3) asphalt pavement structure demonstrates good mechanical and performance characteristics, durability, and resistance to environmental effects.

[0017] The suggested asphalt pavement structure can be used to construct pavements of roads, streets and other traffic zones depending on traffic and service conditions defined in a technical description of its application.

[0018] Reliability of the created pavement structure is directly related to the technological process of its application. The below technical specifications for the materials used in pavement structural layers and their construction works change nothing in the currently valid laws, regulations, normative documents, standards, hygienic norms or other rules and requirements. These are additional technical requirements for individual construction works, products and equipment, also regulations for the quality of works and the use of structure. The following technological process shall be ensured when laying and using the designed pavement structures:

1. Pavement structures have been designed with an assumption that the prevailing soils are of low or average frost-susceptibility and belong to the frost-susceptibility class F2 (very fine sand, sandy clay or similar). At the upper part of subgrade (0,5-1,0 m in depth) compaction ratio D_{Pr} shall be $\geq 100\%$, at the lower part of subgrade from the depth of 1,0 m - $\geq 98\%$. Deformation modulus value of subgrade with soil improvement shall be at least $E_{V2} > 70 \text{ MN/m}^2$ during construction stage. During the service life irrespective of the season or precipitation - $E_{V2} > 45 \text{ MN/m}^2$. During technological process the improvement of existing soils is carried out with the help of binder, depending on the properties of subgrade soils and having determined binder content by laboratory tests. Depending on the methods used the following procedures are recommended to prove suitability: to determine mechanical resistance and stability of soils within the zones of embankment height; uniaxial compressive strength of soils in the upper subgrade zone determined after 28 days shall reach not less than 0,5 N/mm².

2. Thickness of the frost resistant layer (AŠAS) shall be corrected according to the depth of frozen ground and local conditions. The frost resistant layer is constructed by using unbound aggregate mixtures or soils (poorly-graded gravel ŽB, well-graded gravel ŽG, medium-graded gravel ŽP; poorly-graded sand SB, well-graded sand SG, medium-graded sand SP), which shall comply with the following requirements:

- Maximum content of mineral fines $< 0,063 \text{ mm}$ is $\leq 5\%$, category UF5 in accordance with the standard EN 933-1.
- Water permeability $k \geq 2,0 \times 10^{-5} \text{ m/s}$ in accordance with the standard CEN ISO/TS 17892-11.
- Water content in unbound aggregate mixtures and soils before their application and compaction is optimum.

AŠAS shall be constructed in a way to ensure a perfect drainage function of pavement structure during pavement service life. AŠAS shall be constructed and compacted in a way that its bearing and deformation properties are as similar as possible. Moreover, unbound aggregate mixtures or soils shall be unloaded and spread to prevent separation of different fractions (hazardous segregation). The following requirements are applied for compaction ratio

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D_{Pr} and deformation modulus E_{V2} :

- The ASAS upper part (up to 20 cm) shall be compacted to reach the compaction ratio $D_{Pr} > 103\%$, the ASAS lower part (below upper part) $D_{Pr} > 100\%$.
- The ratio E_{V2}/E_{V1} shall not exceed 2,2. A higher value of the ratio is allowable if the value of E_{V1} is not less than 0,6 of the required value of E_{V2} .
- The value of ASAS deformation modulus E_{V2} shall not be less than 100 MPa.

3. Crushed-stone base layer (SPS) is constructed by using unbound aggregate mixtures (fr. 0/45, 0/56), which comply with the following requirements:

- Maximum content of mineral fines $< 0,063\text{ mm}$ is $\leq 5\%$, category UF5 in accordance with the standard EN 933-1.
- For the largest-size fraction the category OC₉₀ according to EN 933-1 is used.
- Water content in unbound aggregate mixtures before their application and compaction is close to optimum.

SPS shall be constructed in a way to ensure that its bearing and deformation properties are as similar as possible. Unbound aggregate mixture shall be unloaded and spread in such way which prevent separation of different fractions (hazardous segregation). The following requirements are applied for compaction ratio D_{Pr} and deformation modulus E_{V2} :

- SPS compaction ratio D_{Pr} shall not be less than 103%.
- The ratio of deformation moduli E_{V2}/E_{V1} shall not exceed 2,2 where the compaction ratio $D_{Pr} \geq 103\%$. A higher value of the ratio E_{V2}/E_{V1} is allowable if the value of E_{V1} is not less than 0,6 of the required value of E_{V2} .
- The value of SPS deformation modulus E_{V2} shall not be less than 150 MPa.

4. Asphalt mixtures shall be produced in accordance with EN 13108-1 or EN 13108-5 and EN 13108-20. Composite materials used to produce asphalt mixtures shall comply with the following requirements:

- Asphalt wearing layer from SMA 11 S mixture:
 - Mineral aggregate: C_{100/0}, SZ18/LA20, PSV₅₀.
 - Binder PMB 45/80-60 (or PMB 25/55-60) shall comply with the EN 14023 requirements, minimum content - 6,4%, binder stabilizing agent - 0,3-1,5%.
 - Air void content - from 2,0 to 3,0%.
- Asphalt binder layer from AC 16 AS mixture:
 - Mineral aggregate: C_{100/0}, SZ₁₈/LA₂₀.
 - Binder PMB 45/80-60 (or PMB 25/55-60) shall comply with the EN 14023 requirements, minimum content - 4,2%.
 - Air void content - from 3,5 to 6,5%.
- Asphalt base layer from AC 22 PS mixture:
 - Mineral aggregate: C_{50/30}.
 - Binder 50/70 shall comply with the EN 12591 requirements, minimum content - 3,8%.
 - Air void content - from 5,0 to 10,0%.

5. For mixture SMA 11 S of asphalt wearing layer it is recommended to use bitumen PMB 45/80-60 (or PMB 25/55-60). Mixtures used for asphalt wearing layers and binder layers shall comply with the resistance to plastic deformations requirements, i.e., to ensure that rut depth determined according to EN 12697-22+A1:2007 at a +50°C temperature after 10000 load cycles is less than 1,5 mm.

6. Asphalt layers shall be laid and compacted to ensure:

- Compaction degree of asphalt wearing layer from SMA 11 S $\geq 98\%$;
- Compaction degree of asphalt binder layer from AC 16 AS $\geq 97\%$;
- Compaction degree of asphalt base layer from AC 22 PS $\geq 97\%$.

7. For bonding of asphalt layers the polymer-modified bitumen emulsion C60BP4-S is recommended to be spread in the amount of not less than:

- 250 g/m² on compacted asphalt binder layer;
- 350 g/m² on compacted asphalt base layer.

The amount of bitumen emulsion can be reduced from 15 to 20 %, if a new asphalt layer is laid immediately after the compaction of preceding layer. Accurate amount shall be determined by additional evaluation of surface condition of asphalt layers.

8. To prove a compliance of mixtures used for asphalt wearing and binder layers to the above requirements, the test of job mix composition type must be carried out for each mixture before using it on-site. Required properties presented in Table 3 should be reached. During construction works the check samples of asphalt mixtures shall be taken from a paver to a box in random order (for every second-third mixing batch).

Claims

1. Asphalt pavement structure, comprising the asphalt wearing layer, binder layer, base layer and unbound mineral material layers, wherein thicknesses of the layers are optimized by mechanical properties of the layers materials and the vehicle axle load of 4 million ESA with the durability of the pavement structure verified by an individually designed model in ViaStructura program, assessing the effects of temperature and load spectra, wherein the asphalt pavement structure comprises layers:

- Asphalt wearing layer (SMA 11 S) - 3,5 cm,
- Asphalt binder layer (AC 16 AS) - 5,0 cm,
- Asphalt base layer (AC 22 PS) - 8,0 cm,
- Crushed-stone base layer (SPS fr. 0/45) - 20,0 cm,
- Frost resistant layer (ASAS) - 40,0 cm,
- Subgrade (ZS) soils of average (F2) frost-susceptibility $E_{V2} \geq 70$ MPa.

2. Asphalt pavement structure, according to the Claim 1, wherein thicknesses of the layers are optimized by mechanical properties of the layers materials and the vehicle axle load of 7 million ESA with the durability of the pavement structure verified by an individually designed model in ViaStructura program, assessing the effects of temperature and load spectra, wherein the asphalt pavement structure comprises layers:

- Asphalt wearing layer (SMA 11 S) - 4,0 cm,
- Asphalt binder layer (AC 16 AS) - 7,0 cm,
- Asphalt base layer (AC 22 PS) - 8,0 cm,
- Crushed-stone base layer (SPS fr. 0/45) - 20,0 cm,
- Frost resistant layer (ASAS) - 40,0 cm,
- Subgrade (ZS) soils of average (F2) frost-susceptibility $E_{V2} \geq 70$ MPa.

DK 10-4

	3,5 cm	SMA 11 S
	5,0 cm	AC 16 AS
	8,0 cm	AC 22 PS
	15,0 cm	SPS fr. 0/45
	40,0 cm	AŠAS
	-	ŽS (F2)

FIG. 1

DK 10-7

	4,0 cm	SMA 11 S
	7,0 cm	AC 16 AS
	8,0 cm	AC 22 PS
	20,0 cm	SPS fr. 0/45
	40,0 cm	AŠAS
	-	ŽS (F2)

FIG. 2

DK 10-10

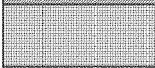
	4,0 cm	SMA 11 S
	8,0 cm	AC 16 AS
	10,0 cm	AC 22 PS
	20,0 cm	SPS fr. 0/45
	40,0 cm	AŠAS
	-	ŽS (F2)

FIG. 3



EUROPEAN SEARCH REPORT

 Application Number
 EP 19 20 2509

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	Anonymous: "Richtlinien für die Standardisierung des Oberbaus von Verkehrsflächen RSt0 12", 31 December 2012 (2012-12-31), Forschungsgesellschaft für Strassen- und Verkehrswesen, XP002799241, ISBN: 978-3-86446-021-0 pages 1-52, * the whole document *	1,2	INV. E01C7/18
A	Anonymous: "Richtlinien für die rechnerische Dimensionierung des Oberbaus von Verkehrsflächen mit Asphaltdeckschicht RDO Asphalt 09", 31 December 2009 (2009-12-31), Forschungsgesellschaft für Strassen- und Verkehrswesen, XP002799242, ISBN: 978-3-941790-15-5 pages 1-34, * the whole document *	1,2	
A	Anonymous: "Zusätzliche Technische Vertragsbedingungen und Richtlinien für den Bau von Verkehrsflächenbefestigungen aus Asphalt ZTV Asphalt-StB 07/13", 31 December 2013 (2013-12-31), Forschungsgesellschaft für Strassen- und Verkehrswesen, XP009520791, ISBN: 978-3-939715-68-9 pages 1-76, * the whole document *	1,2	TECHNICAL FIELDS SEARCHED (IPC) E01C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 23 June 2020	Examiner Beucher, Stefan
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03.82 (P04C01)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

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- Development of Asphalt Pavement Design Model and its Application Software. *ViaStructura*, 2018 **[0005]**