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(54) COMPOSITE MODULE FOR PEDESTRIAN AND BICYCLE TRAFFIC ZONES AND ITS BUILDING METHOD

(57) The object of the invention is to provide an asphalt/concrete composite modules (slabs) for the installation of footpaths, sidewalks, pedestrian and bicycle paths, complying with specific requirements for dimensions, convenient and fast installation or replacement, durability, slip resistance, comfortable in respect of traffic and low cost.

Asphalt/concrete composite module (slab) is made of a layer (2) of a cement concrete module (slab) having thickness of 65 mm, which is made of conventional cement concrete of C30/37-C40/50 compressive strength class with the addition of 0.6 to 1.1 kg/m^3 of micro-fibers and 3 to 5 kg/m^3 of macro-fibers, installed on a conventional base (unbound base layer, or hydraulically or bituminous bound base) layer (3), ensuring a static deformation modulus of at least 100 MPa and a compaction coefficient of at least 100%, characterized in that the cement/concrete module (slab) is equipped with the anti-slip layer of asphalt mixture (1), asphalt/concrete composite modules (slabs) are available in 4 sizes, and the joints between the modules (slabs) are filled with sealants.

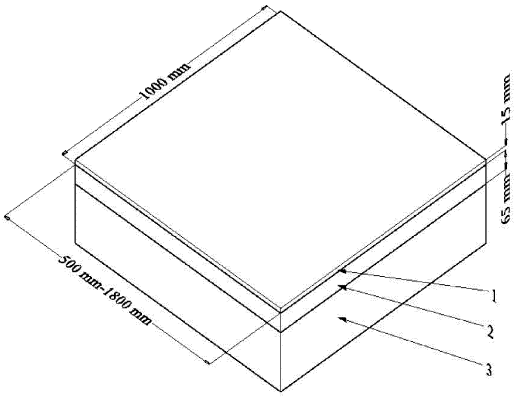

FIG. 1.

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Description

TECHNICAL FIELD

[0001] The invention belongs to the field of construction industry, more precisely, to an asphalt/concrete composite modules (slabs) used for pedestrian and bicycle traffic areas (footpaths, sidewalks, paths for bicycles and pedestrians, and bike paths) having specific requirements for size and thickness, stricter requirements for durability, reduction of slipperiness, assurance of traffic safety and comfort of movement. Also, for reducing the need for structure maintenance and maintenance costs.

BACKGROUND ART

[0002] It is known that in order to ensure the safe movement of vulnerable road users, it is very important to arrange pedestrian and bicycle traffic areas with the right parameters. Proper drainage of the surface (rain) water and pavements that provide sufficient grip and resistance to slip significantly reduce the risk of accidents with severe consequences.

[0003] The surface of footpaths in squares, parks and other public spaces must be solid, stable, non-slip when wet, and the rainwater must not accumulate on it (see Construction technical regulation STR 2.03.01:2019 "Accessibility of Buildings" approved by Order No. D1-653 of the Minister of Environment of the Republic of Lithuania of 4 November 2019 "Regarding the approval of the Construction Technical Regulation STR 2.03.01:2019 "'Accessibility of Buildings". Choosing pavement types and materials must ensure that they have sufficient and long enough wheel grip with the pavement, as well as sufficient long-term resistance to slip. It should also be taken into account that the pedestrian areas or paths, especially in front of shop windows or on ramps, should have the necessary resistance to slip (see The Rules for the Installation of Road Pavement Structures of Pads and Slabs, T 14) approved by Order of the Director of the Lithuanian Road Administration under the Ministry of Transport and Communications of 21 February 2014 No. V-71 "On the Approval of The Rules for the Installation of Road Pavement Structures of Pads and Slabs, T 14".

[0004] There are known cement concrete slabs for paving streets, roads, highways and highways, when a cement/concrete mixture is poured on an installed and prepared base and a pavement is formed. The width of the cement concrete slab is selected according to the standard or average distance between the wheels of the front or rear axle of the truck, whichever is smaller. And the length of the cement concrete slab is chosen according to the smallest distance between the front and the rear axles of the truck. This way, the width and the length of the cement/concrete slab can be from 0.50 m to 3.50 m. The thickness of the cement concrete slab is selected according to the deformation modulus determined by the compressive strength of the cement concrete mix, traffic loads, base quality and soil type. These cement concrete slabs can be formed on a conventional base - unbound mixture, or mixture bound by cement or bituminous binder (see WO 2007/042338 A1, pub. 2007-04-19).

[0005] The pavement formed from these cement concrete slabs is resistant to heavy transport loads, as the cement/concrete slab will always be affected by the load of one wheel or only one chassis of the truck. However, the installation of this type of pavement is a slow process, as the cement concrete slabs are formed on an installed and prepared base by pouring and compacting the cement/concrete mix. In addition, the repair of such a cement-concrete slab pavement is not possible by replacing a damaged cement-concrete slab, thus its repair requires timely traffic restrictions and technological processes and materials.

[0006] There are known prefabricated cement concrete slabs for paving, which can be used for quick and convenient construction, repair and maintenance, and which are durable and cost-effective. Prefabricated cement concrete slabs, each of which is adapted to the width of the road, can be easily transported to the construction site and mounted by using lifting equipment installed on each slab unit. Also, each cement concrete slab is fitted with dowels to firmly connect the slab blocks. Watertight elements that prevent water from penetrating to the base are installed between the continuously connected adjacent slabs. Therefore, the road surface made of cement concrete slabs can be easily repaired or replaced in a cost-effective way. Also, the road surface can be improved to achieve a smooth surface (see U.S. Pat. No. 6688808 B2, pub. 2004-02-10).

[0007] The pavement formed from these cement concrete slabs has sufficient resistance to heavy transport loads, but such pavement of cement concrete slabs has too high load bearing capacity for a bicycle and/or footpath or pedestrian pavement, making the installation of these cement concrete slabs not cost-effective for such buildings.

[0008] Also, cement concrete slabs are known for quick road pavement installation and subsequent quick maintenance and repair. These cement concrete slabs are 3-5 m wide and 25-35 cm thick, therefore, in order to prevent deformation during the installation of the road surface or its replacement during repairs, a reinforcement grid is installed in the lower part of the slab at a distance of 5 cm from the lower surface. Also, each cement concrete slab is fitted with dowels that protrude 20-50 cm from the surface on the sides of the cement concrete slab and are designed to firmly connect the slab blocks (see CN203514143U, pub. 2014-04-02).

[0009] Cement concrete slabs of this type are not suitable for light load traffic areas, such as footpaths, sidewalks, or bicycle paths.

[0010] There is a known high-strength cement-concrete mix for the installation of road surfaces, which is particularly resistant to high static and dynamic loads. Such strength of the cement concrete mix is achieved by the addition of metal fibers that strengthen the carcass and provide resistance to crack formation (see US6080234A, publ. 2000-06-27 and US6887309B2, publ. 2005-05-03).

[0011] Cement concrete mix with metal fibers has good mechanical properties, as well as good resistance to static and dynamic loads, but metal fibers make it difficult to ensure the required surface texture and surface grip of the cement concrete slab.

[0012] The closest samples are cement concrete modules (slabs), which are made of ordinary cement concrete mix with micro and macro fibers, and are without dowels and are not interconnected, installed on a conventional base - unbound mix, or a mix bound by cement and/or bituminous binder (see LT 6720 , publ. 2020-03-25).

[0013] The prototype has specific requirements for size and thickness, convenient and quick installation on a conventional base, convenient and quick replacement (in case of repair), possible different surface texture and resistance to slip, and durability, and a low cost. However, the texture of these modules is not deep. During rain, the surface (rain) water entering the pedestrian and bicycle traffic areas from the cement concrete modules (slabs) forms a water film, therefore the paths installed from these modules may not be sufficiently resistant to slip, and there is a risk for vulnerable road users to slip and injure themselves. In addition, the joints of cement concrete modules (slabs) of traffic area coverings are usually not sealed, therefore the joints become contaminated with foreign materials and plant vegetation takes place in warm weather. In addition, gaps (seams) in the pavement reduce the comfort of vulnerable road users.

[0014] Conventional cement concrete pavement is smooth and slippery, especially in adverse weather conditions, in case of precipitation, when the surface (rain) water on the pavement surface reduces the slip resistance of the pavement. In order to increase the slip resistance in pedestrian traffic areas with concrete pavements, surface roughening is often performed by using mechanical means, such as the "broom" method (see Frederick R. Steiner, Kent Butler. Planning and Urban Design Standards, Student Edition. American Planning Association. 2006). This increases the grip characteristics, but the surface texture of the concrete pavement thus obtained does not provide sufficient surface (rain) water drainage, so a layer of water is formed on the surface of such pavement, which reduces the resistance to slip.

[0015] It is known that the surface texture of an asphalt pavement is directly related to slip resistance. Small unevenness of the filler particles in the asphalt mixture prevents the formation of a continuous water film, which increases the slip resistance of the pavement (see. Malal Kane, Ignacio Artamendi, Tom Scarpas. Long-term skid resistance of asphalt surfacings: Correlation between Wehner-Schulze friction values and the mineralogical composition of the aggregates. Wear 303 (2013) 235-243). The texture depth of the asphalt pavement is greater than that of the concrete pavement. The surface of asphalt pavements has grooves through which surface (rain) water drains from the pavements, therefore, in the presence of rain of normal intensity, no water layer is formed on the tracks. In addition, asphalt pavement is more elastic than concrete pavement, making asphalt pavement paths more comfortable for both pedestrians and cyclists.

SUMMARY OF INVENTION

[0016] The object of the invention is to provide an asphalt/concrete composite modules (slabs) for the installation of footpaths, sidewalks, pedestrian and bicycle paths, bicycle path pavements, complying to specific requirements for size and thickness, convenient and fast installation on a conventional base - unbound base layer, hydraulic or bituminous binder-bonded base layer, convenient and fast replacement (in case of repair), durability, slip resistance, comfortable in respect of traffic and low cost. The aim of the invention is achieved by implementing the project "Modular Pavements" financed from the European Regional Development Fund (Project No. 01.2.2-LMT-K-718-01-0044) according to the grant agreement with the Lithuanian Science Council (LMTLT).

[0017] This goal is achieved by producing 4 sizes of asphalt/concrete composite modules (slabs), the dimensions of which are selected according to the requirements for pedestrian and bicycle traffic areas to ensure functionality:

- asphalt/concrete composite module (slab) width - 500 mm, length - 1000 mm, and thickness - 80 mm;
- asphalt/concrete composite module (slab) width - 1000 mm, length - 1000 mm, and thickness - 80 mm;
- asphalt/concrete composite module (slab) width - 1200 mm, length - 1000 mm, and thickness - 80 mm;
- asphalt/concrete composite module (slab) width - 1800 mm, length - 1000 mm, and thickness - 80 mm;

[0018] Also, the goal is achieved by using cement concrete modules (slabs) in asphalt/concrete composite modules (slabs) (see LT 6720, publ. 2020-03-25), which are without dowels and are not interconnected, are installed on a conventional base - unbound base layer, or hydraulically or bituminous bound base layer, the bearing capacity of which, determined in accordance with the requirements of standard LST 1360-5, is as follows: deformation modulus $Ev_2 \geq 100$ MPa, and/or the degree of compaction determined in accordance with the requirements of standards LST 1360.6 and

LST EN 1360-2 is $D_{Pr} \geq 100\%$. Cement concrete modules (slabs) weigh 150-300 kg, depending on the cement concrete mix used, so they are installed and, if necessary, replaced (in case of repair) by using the vacuum or oppressive hoists, i.e. no additional metal loops are required. These cement concrete modules (slabs) must be made of a conventional mixture of cement concrete with micro and macro fibers. Conventional cement concrete is manufactured in accordance with the relevant technical documents and/or standards and have a compressive strength class from C30/37 to C40/50. Typically, such a cement concrete mix has a compressive strength of 35 MPa to 55 MPa and a flexural strength of 4 MPa to 6 MPa. To the conventional cement concrete mix, 0.6-1.1 kg/m^3 of micro-fibers (e.g. 0.8 kg/m^3) and 3-5 kg/m^3 of macro-fibers (eg 4 kg/m^3) are added. The mechanical properties of such cement concrete mixture with micro and macro fibers must meet the requirements given in Table 1:

Table 1. Required mechanical properties for cement concrete with micro and macro fibers.

Feature	Standard	Value required
Compressive strength after 7 days, MPa	LST EN 12690-3	≥ 30.0
Flexural strength with splitting after 7 days, MPa	LST EN 12690-5	≥ 3.5
Compressive strength after 28 days, MPa	LST EN 12690-3	≥ 45.0
Flexural strength including splitting, after 28 days, MPa	LST EN 12690-5	≥ 5.0

[0019] Also, the goal is achieved by installing at the factory a 15 mm thick layer of asphalt mixture on the manufactured modules. The composition of the asphalt mixture (see LT 6724, publ. 2020-04-10) includes a mixture of aggregates from fractionated crushed stone and mineral filler, a adhesive agent, a cellulose fiber and a polymer-modified bitumen, when the components have a weight % ratio as follows:

- 2-5 mm granite crushed stone fraction - 75.0-86.0,
- 0-2 mm sieved granite chippings fraction - 7.0-14.0,
- mineral filler- 1.0-5.0,
- adhesive agent - 0.01-0.03,
- cellulose fiber - 0.30-0.60,
- bitumen - 5.0-6.5.

[0020] The goal is also achieved by the aggregate size distribution of said mixture of aggregates, which have a weight % ratio as follows:

- passing a 0.063 mm sieve - 3.0-8.0,
- passing a 0.125 mm sieve - 4.0-9.0,
- passing a 0.250 mm sieve - 5.0-10.0,
- passing a 0.5 mm sieve - 6.0-12.0,
- passing a 1.0 mm sieve - 7.0-13.0,
- passing a 2.0 mm sieve - 11.0-18.0,
- passing a 5.6 mm sieve - 85.0-100.0,
- passing an 8.0 mm sieve -100.0.

[0021] These asphalt mixtures have good mechanical and performance properties.

[0022] Also, the goal is achieved by sealing the joints formed between the asphalt-concrete composite modules (slabs) with seals (bitumen, silicone or epoxy-based). In this way, the edge of the asphalt pavement is stabilized and the joints of the slabs are protected from contamination by foreign materials, preventing plant vegetation in the joints. The maintenance of such traffic areas will be easier. In addition, sealing the joint gaps will make the pavement smoother, the edges of the modules (panels) will be safer, and the pedestrian and bicycle traffic will be more comfortable. Paths made of asphalt/concrete composite modules (slabs) are superior to the conventional paved asphalt pavement paths in that they are easier to install and maintain, i.e. it is not necessary to frame the paths by curbs, and installation can take place even in cold weather.

[0023] The concept of asphalt/concrete composite modules (slabs) for the installation of pavements for bicycles and/or footpaths and sidewalks presented in the invention is illustrated by the example.

DESCRIPTION OF DRAWINGS

[0024]

FIG. 1. Asphalt/concrete composite module.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

1 Example of asphalt/concrete composite module (slab)

[0025] Fig. 1 shows an asphalt/concrete composite module (slab) according to the invention.

[0026] The developed asphalt/concrete composite modules (slabs) have good mechanical and performance characteristics, durability and low cost.

[0027] The present invention can be applied to install the pavement for bicycles and/or footpaths and sidewalks and other traffic areas where there is no traffic of heavy transport.

[0028] It should be understood that many specific details are set forth in order to provide a complete and understandable description of the exemplary embodiment of the invention. However, it will be clear to a person skilled in the art that the details of the examples of implementation of the invention do not limit the implementation of the invention, which can be implemented without such specific instructions. Well-known methods, procedures, and ingredients have not been described in detail so that examples are not misleading to the implementation of the invention.

Claims

1. Pavement for pedestrian and bicycle paths and footpaths, comprising a layer (2) of concrete slabs made of the cement concrete with compressive strength class C30/37-C40/50 with the addition from 0.6 to 1.1 kg/m^3 of microfibers and from 3 to 5 kg/m^3 of macro-fibers, installed on an unbound base layer or hydraulically or bituminous bound base layer (3), ensuring a static deformation modulus of at least 100 MPa, **characterized in that**

   - the concrete slabs of the layer (2) further comprise the wearing anti-slip layer of asphalt mixture (1), and
   - the joints between said concrete slabs are filled with sealant.

2. The pavement according to claim 1, **characterized in that** the wearing anti-slip layer of asphalt mixture (1)comprises a adhesive agent, a cellulose fiber, a polymer-modified bitumen and a mixture of aggregates from fractionated crushed stone and mineral filler comprising a fraction of 2-5 mm granite crushed stone, and 0-2 mm sieved granite chippings and mineral powder, wherein said components have a weight % ratio as follows:

   • 2-5 mm granite crushed stone fraction - 75.0-86.0,
   • 0-2 mm sieved granite chippings fraction - 7.0-14.0,
   • mineral filler- 1.0-5.0,
   • adhesive agent - 0.01-0.03,
   • cellulose fiber - 0.30-0.60,
   • bitumen - 5.0-6.5.

3. The pavement according to Claim 1, **characterized in that** the aggregate size distribution of said asphalt mixture of aggregates has a weight % ratio as follows:

   • passing a 0.063 mm sieve - 3.0-8.0,
   • passing a 0.125 mm sieve - 4.0-9.0,
   • passing a 0.250 mm sieve - 5.0-10.0,
   • passing a 0.5 mm sieve - 6.0-12.0,
   • passing a 1.0 mm sieve - 7.0-13.0,
   • passing a 2.0 mm sieve - 11.0-18.0,
   • passing a 5.6 mm sieve - 85.0-100.0,
   • passing an 8.0 mm sieve -100.0.

4. The pavement according to Claims 1 to 3, **characterized in that** the preferred sizes of the concrete slabs with the wearing asphalt mixture layer are, at least, these:

- slab width - 500 mm, length - 1000 mm, and thickness - 80 mm;
- slab width - 1000 mm, length - 1000 mm, and thickness - 80 mm;
- slab width - 1200 mm, length - 1000 mm, and thickness - 80 mm;
- slab width - 1800 mm, length - 1000 mm, and thickness - 80 mm.

5. The pavement according to claim 4, **characterized in that** the preferred thickness of the concrete layer is 65 mm.

6. The pavement according to claim 4, **characterized in that** the preferred thickness of the asphalt mixture layer is 15 mm.

7. The pavement according to claim 1, **characterized in that** said pavement slabs are without dowels and not interconnected, and the joints between said pavement slabs are filled with a sealant.

8. The pavement according to claims 1 and 7, **characterized in that** said sealant is used to fill joints between said pavement slabs is bitumen, silicone or epoxy-based sealant.

9. A method for building the pavement of claims 1 to 8, comprising at least of these steps

- preparing an unbound base layer or hydraulically or bituminous bound base layer (3), ensuring a static deformation modulus of at least 100 MPa and a compaction coefficient of at least 100%
- installing the layer (2) of said pavement slabs without dowels and without interconnections,

characterized in that

- further the joints between said installed pavement slabs are filled with the sealant.

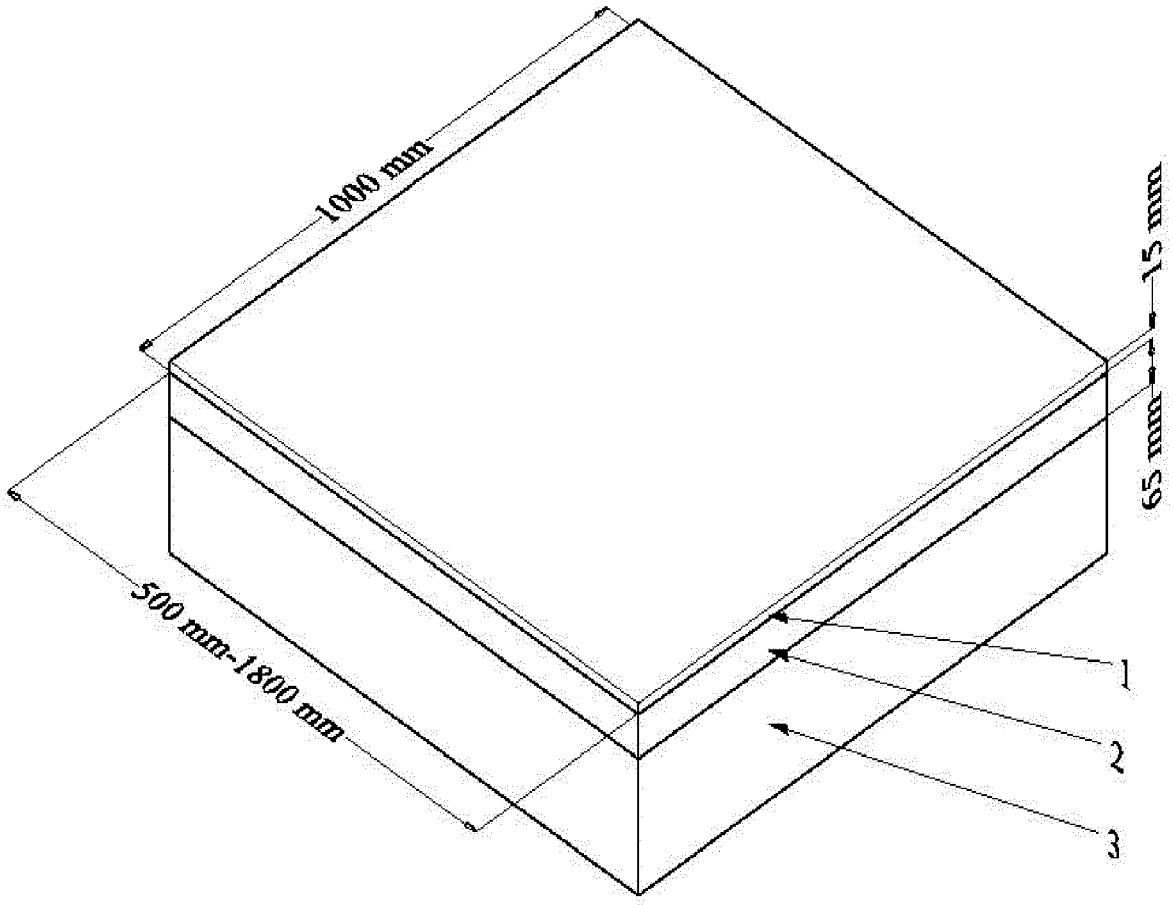

FIG. 1.

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EUROPEAN SEARCH REPORT

Application Number
EP 21 17 9480

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y,D	LT 6 720 B (UNIV VILNIAUS GEDIMINO TECH [LT]) 25 March 2020 (2020-03-25)	1,3-9	INV. E01C5/22
A	* the whole document *	2	
Y	CN 108 978 388 A (UNIV SCIENCE & TECHNOLOGY LIAONING) 11 December 2018 (2018-12-11)	1,3-9	
A	* paragraphs [0001], [0007], [0008], [0011], [0012], [0013], [0023] - [0026], [0034] - [0038], [0041] - [0046] * * claims 1,5,6,7; figures 1,2 *	2	
Y	GB 253 602 A (CHARLES FROBISHER; EDMUND AINSWORTH KILSHAW) 21 June 1926 (1926-06-21)	1,3-9	
A	* page 1, lines 9-63 * * page 2, lines 6-32 * * page 3, paragraph 24-56 * * page 3, lines 64-68 * * figure 1 *	2	TECHNICAL FIELDS SEARCHED (IPC)
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A	* page 1, lines 1-13,24-53 * * page 2, lines 17-34,55-64,77-82 * * figures 6,8 *	2	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 November 2021	Kremsler, Stefan

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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& : member of the same patent family, corresponding document

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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17-11-2021

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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