HEXAGONAL ROADWAY SYSTEM AND TRAFFIC CONTROL SYSTEM THEREOF

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ABSTRACT

The present invention relates to the urban roadway system and accompanying underground railway system, which provide the efficient use of limited constructible areas of the congested cities, and also relates to the traffic flow control system capable of the effective control of vehicular movements through the roadways. In the whole or partial areas of a city, the roadway network is constructed and connected in the honeycomb-like net structure. Compared with a typical tetragonal city, the hexagonal city of the present invention can reduce 22% of road extent, 63% of road area and 30% of constructible area in total, and the traffic flow can be improved enormously. The present invention also proves that the hexagonal roadway system enables vehicles to move in average 75% less time without meeting stop-signals by the synchronized signal system for traffic flow controls.
HEXAGONAL ROADWAY SYSTEM AND TRAFFIC CONTROL SYSTEM THEREOF

TECHNICAL FIELD

[0001] The present invention relates to the urban roadway system and accompanying underground railway system, which provide the effective use of limited constructible areas of the congested cities, and also relates to the traffic flow control system capable of the effective control of vehicular movements through the roadways.

BACKGROUND ART

[0002] Using tools and machine, human beings customarily made things out of lines and tetragons. And furthermore, for thousands of years they have filled their surrounding spaces with the artifacts shaped in rectangles except in the case for incidental ornaments. Densely populated cities have been so constructed with the roadways inter-connecting the main placed of their districts directly as to have many crossroads. All the traffic problems caused by the expanded supply of automobiles have been regarded as the inevitable products of modern civilization. So far as every intersection of a conventional roadway system in concerned, it has been problematic even for a highly advanced computer system to establish a complete traffic flow control system which should combine 12 traffic-lines plus bi-directional 4 crosswalks.

[0003] Meanwhile, nature pursues circles (in 2-dimensional planes) and spheres (in 3-dimensional spaces). But no perfect circles and spheres exist because of the effect of external forces. In such a realm of nature, the structure of a snowflake or a honeycomb comprises many hexagonal cells. The most efficient forming out the cohesion of identical circles in a plane is exactly the hexagonal net structure like a honeycomb. This is the result of a transformation that the gaps between mutually Circumscribed circles were thrust and shrunk by the dominant external forces applied.

[0004] By means of applying the hexagonal net structure found from one of nature’s phenomena to mankind’s customary societies from the dawn of civilization, creating more efficient urban spaces is to be the technological secret of the present invention.

DISCLOSURE OF THE INVENTION

Technical Problem

[0005] When humans move in the spaces with intersecting lines over planes of artificial polygons, there always exist the ineffective parts of times and spaces which decrease the efficiency of movement. On this point of view, the times and spaces of necessary evils, both of which are required for operating the vehicular media that are not the best means for the physical movements of humans, are defined to be ineffective times and ineffective spaces, respectively.

[0006] The kernel of the present invention is to find technical solutions through analyzing those ineffective times and spaces quantitatively with respect to the properties of two different types of the urban roadway systems proposed as follows.

[0007] A typical roadway network configured and connected in the tetragonal net structure is defined to be the tetragonal roadway system, and likewise, the other is defined to be the hexagonal roadway system. Assuming two different types of cities, defined herein as the tetra-city and the hexa-city, which correspond to the respective roadway systems mentioned above, the present invention provides solutions to the following three main problems.

[0008] First: To derive the method for reducing ineffective spaces of urban areas through renovating the structure of roadway networks.

[0009] Second: To derive the method for reducing ineffective times of urban areas through renovating the structure of roadway networks.

[0010] Third: To establish the technical basis to obtain economical and political validity and fairness in governmental city planning with regards to the overall renovation of the urban spaces including public facilities over and under ground, in accordance with the renewal of the roadways.

Technical Solution

[0011] In the whole or partial areas of the city to which the present invention is applied, the roadway network is constructed and connected in the net structure of hexagonal meshes like the cross-section of a honeycomb. Inside each hexagonal unit-block (abbreviated as block, hereinafter) surrounded by inter-block roads constituting the roadway network mentioned above, inner-block roads and other architectural facilities are placed. And orthogonal roads, circular roads and other local roads constitute the group of inner-block roads mentioned above.

[0012] The areas divided by the inner-block roads are allocated for buildings or facilities, which are suitable for the topographic or geographic properties of the block, and the roads beside them are connected to the respective circular roads. The central land of the block can be provided for a plaza, park, school site, library, or other facilities of public use.

[0013] As represented in FIG. 1, each orthogonal road (104) connects the central part of a block (106) with those of other adjacent blocks, and intersects the corresponding inter-block roads (102). The circular roads (not depicted) of a block are arranged in the appropriate intervals one another, and intersect the respective orthogonal roads of the same block.

[0014] Each crosswalk (or pedestrian crossing) of the hexa-city, being on the inter-block roads, are allowed to equip with a mid-safety island for pedestrian’s time-lag crossing (Refer to FIG. 5).

[0015] Underground railways (108) are installed under the orthogonal roads with possible entrance of two different lines of the railways on the parallel lines of a platform in a station. And stations for them are built under a central plaza or a certain intersection of crossroads (Refer to FIG. 1).

[0016] The tetra-city divides the lanes of a road into three directions as left, forward and right, while the hexa-city divides into two as left and right. Accordingly, the numbers of lanes required between the two cities are in the ratio of 3:2, i.e. simply, the lane ratio is 3/2. The reasonable allocation of lanes of roads has become the key to the traffic policy of the traditional tetra-city.

[0017] Relying on the regulations of determinations, structures, and installation standards for facilities of urban planning (the ordinance #14 of the ministry of construction and transportation, republic of Korea), the articles for roads are as follows (extracted and abstracted).

Article 9-2. Sort of Roads by Width

[0018] a. Wide road: 40 meters or more, 12 lanes or more

[0019] b. Large road: 25 meters or more, 8 lanes or more
c. Medium road: 12 meters or more, 4 lanes or more  
d. Small road: Others

Article 9-3. Sort of Roads by Functional Grade

Main arterials, auxiliary arterials, collectors, local roads, etc

Article 10. Placement Distance for Roads of a Grade

Stepped down respectively by grade: 1000, 500, 250, 125, 60, 25 (meters).

Article 11. Road Ratio According to Zoning, Adjustable When Demanded

1. Residential zone: 20% to 30%, including 10% to 15% of main arterials
2. Commercial zone: 25% to 35%, including 10% to 15% of main arterials

It has been widely recognized that the road ratio trades off the traffic flow for the land usage. But the radical problem concerning the road ratio of the tetra-city is being unable to get out of the structural limit, which requires lanes in the ratio of 3:2, even though simply compared with a hexa-city.

Therefore, the upper-limit values of the respective road ratios mentioned above, which would minimize the degree of traffic congestion of the tetra-city, are herein quoted to analyze the road ratios of the two different cities.

The criterion of the road ratio of the tetra-city is presumed to be 32.5% that is the arithmetic mean value of the two upper-limit road ratios of the most congested zones, both of which are the main targets to apply the present invention. The assigned road ratios to main-arterials, auxiliary-arterials and inner-block roads are 12%, 8%, and 12.5%, respectively (from the sum 32.5%).

The above-mentioned values were determined through minute analysis on the relevant regulations of the current ordinances for the tetragonal roadway system. The sum of the road ratios of arterials was rounded off as 20%, though calculated as 20.28%.

Setting up the road ratio of the tetra-city is equivalent to the presumption that the uniform expansion of the four sides of a tetragon block with 0 road width (no road areas) makes as much outer area as the portion of the road ratio.

In every numerical expressions, hereinafter, \( N \) is defined as the square root of \( N \), and \( 1/2 \) expression as the square root of the expression.

When the side-length ratio is defined as the ratio between the side lengths of two different regular-polygon blocks of equal effective area, the side-length ratio of a tetra-city to a hexa-city is \( \sqrt{3} \) (about 1.732). The side length of 540 meters of the tetra-city corresponds to that of about 312 meters of the hexa-city. The diameter of inscribed circle of each block is identical as 540 meters in this example (Refer to FIG. 3 and FIG. 4).

In addition, under the assumption that the road width is proportional to the placement distance of roads as quoted in the Article 10, the proper numbers of traffic lanes for the respective road grades are set as below.

Placement distance (m): 1000, 500, 250, 125, 60, 25 (reduced by ½ per step)

Grade index (lanes): 12, 10, 8, 6, 4, 2 (reduced by 2 lanes/step)

The road ratio of main arterials is in proportion to the road width and the perimeter of the block, and the road width is in proportion to the number of lanes and the grade index according to the block’s side length. Therefore, the road ratio of main arterials of hexa-city to tetra-city can be written as:

Road ratio of main arterials of tetra-city to road-width ratio (L/R lane ratio×G/R grade index ratio)×P/R perimeter ratio, that is

\[ \frac{20\% \times (\sqrt{3}) \times (8+((10-8) \times (289-250)/(500-250)))}{10} \times \frac{6}{(1/3)} \times 9.6\% \]

L/R G/R P/R

On account of the profitable structure of the hexa-city, the lanes of each inner-block road can be assigned simply to the two, forward or right, of three kinds of traffic-lines except lanes for left. Accordingly, the inner-block road ratio of hexa-city can be written as below.

Inner-block road ratio of tetra-city×lane ratio×perimeter ratio, that is

\[ 12.5\% \times (\sqrt{3}) \times (6 \times (1/3)) \times 9.6\% \]

Conclusively, the side-expansion ratio, determined by the sum of road ratio of hexa-city, can be calculated as follows.

\[ \sqrt{\frac{100}{100+16.8}} \times 100\% = 109.6\% \]

Above assumptions are applied to the following proposition 1.

Proposition 1

The respective areas of a circle of diameter of 2 (in any units), both regular-hexagon and regular-tetragon, circumscribing the circle, are about 3.14 (=π×1×1), 3.46 (=2,3) and 4.

Then, the following are derived.

Proportional area of tetra-city including roads:

4×(1.217×1.217) = 5.92

Proportional area of hexa-city including roads:

3.64×(1.096×1.096) = 4.16

Area ratio of tetra-city to hexa-city: 5.92/4.16 = 1.42

Ineffective area ratio of tetra-city: (5.92-3.14)/3 = 4×100% = 89%

Ineffective area ratio of hexa-city: (4.16-3.14)/3 = 4×100% = 32%

Ineffective area ratio of tetra-city to hexa-city: 89/32 = 2.78

Proportional road area of tetra-city: 5.92-4 = 1.92

Proportional road area of hexa-city: 4.16-3.46 = 0.70

Road area ratio of tetra-city to hexa-city: 1.92/0.70 = 2.74

Conclusively, the tetra-city contains ineffective spaces, constructable areas and road areas at the respective ratios of 2.78 (36.0%, in reverse), 1.43 (70.0%, in reverse) and 2.74 (36.4%, in reverse) as compared with the hexa-city.

Vehicles and pedestrians of the tetra-city always take detours out of tetragonal corners, which cause unpredictable vehicular contacts and pedestrian contacts. The greater problem is that the ineffective spaces are transmitted to the dark backside so as to speed up increasing slums.
And next, to compare the average extent (length) of roadways between the two cities, the proposition 2 is introduced.

**Proposition 2**

The respective perimeters of a circle of diameter of 2 (in any units), both regular-hexagon and regular-tetragon, circumscribing the circle, are about 6.28(=2π), 6.93(=12√3) and 8.

Also, the following is obtained.

Roadway extent ratio of tetra-city: 8×1.217=9.74
Roadway extent ratio of hexa-city: 6.9×1.096=7.60

Therefore, the vehicles of the tetra-city take detours on the long roadways of the ratio of about 1.28 (78.1%, in reverse) to those of hexa-city.

In a 4-way intersection of the tetra-city, the traffic control system processes 12 traffic-lines, 3 lines (left-turn/forward/right-turn) per way, in a signal-cycle. And in a 3-way intersection of the hexa-city, it processes 6 traffic-lines, 2 lines (left-turn/right-turn) per way, in a signal-cycle.

As the ratio of traffic-lines is 12:6 and the ratio of needed lanes per roadway is about 2:1, as is often the case that lanes for right-turn are neglected, tetra-city requires 4 times longer signal-cycle than the hexa-city.

The optimum solution to the traffic control system is defined as a system which allows a group of vehicles to pass the consecutive intersections without stopping regardless of driving distance and direction on the roadway network under the unified traffic controls.

Though an optimum solution to the traffic control system for the tetra-city does not exist, there exist the solution for the hexa-city that has the equivalent symmetric roadway network.

Under the following prerequisite conditions, the present invention proves the existence of the optimum solution for the unitaryhexagonal roadway network (abbreviated as road-net, hereinafter) under the unified traffic control of the hexa-city. A section is defined as a segment of the inter-block road between the two adjacent 3-way intersections.

Condition 1. Every inter-block road of the road-net contains at least 2 lanes per way (or side of a roadway), and each intersection contains 3 different inter-block roads.

Condition 2. Each intersection, except in outskirts or borderlands of the road-net, is connected with three adjacent intersections of a kind through above-mentioned inter-block roads.

Condition 3. The course of a vehicle toward a distant destination is completed through alternating turns between left and right at each intersection.

Condition 4. In order to change or amend the direction of above-mentioned course, exceptional turns against condition 3 can be selected.

Condition 5. The signal-cycle on every intersection of the road-net is identical, and 1 signal-cycle consists of 3 signal-units.

Condition 6. The allowable speed for vehicles and the length of signal-cycle are adjustable to cover 2 sections per signal-cycle.

Condition 7. Each crosswalk (or pedestrian crossing) can be equipped with mid-safety island for pedestrian’s time-log crossing.

Under the above seven conditions, passing two sections in a signal-cycle makes vehicles repeat identical traffic condition. Passing two sections in a signal-cycle is equivalent to passing ½ sections in a signal-unit.

The order of left-turn for each traffic-line on an intersection complies with the traffic-line numbers, counterclockwise (Refer to FIG. 5). Though each intersection contains three different roads, a pair of traffic-lines running on either side of a roadway has the same traffic-line number (Refer to FIG. 6).

The hexagonal roadway network, differs from the tetragonal roadway network, every one of the 6 traffic-lines exclusively occupies its own lane (or lanes) in an intersection (Refer to FIG. 6).

The unique method for the optimal traffic flow control is as follows. By one and one sequence for the three pairs of traffic lines, the vehicles of each pair of traffic-lines simultaneously pass overall intersections of unitary roadway network with left-turn during a signal-cycle (Refer to FIG. 7).

The three adjacent intersections to a certain intersection, which is occupied by the left-turning traffic-line, are occupied by the reverse traffic-line of the same pair. Concurrently, the vehicles of other pairs of traffic-lines are running on other roads or passing intersections with right-turn (Refer to FIG. 7).

With the above-mentioned system of signal synchronization on the unitary roadway network, it is possible for a group of vehicles to pass intersections alternately in a signal-cycle without stopping.

**ADVANTAGEOUS EFFECTS**

Ceaseless widening of roads in conventional tetracities comes from the fact supposing the road-capacity for entering cars during congestion of an intersection. The increase of traffic lanes forces drivers to choose one of the lanes. However, drivers are used to choose the middle lanes unintentionally. For such a reason, assigning more middle lanes causes the lack of left or right lanes, which results in another traffic problem. As the signal lights turn on in an intersection, changing lanes occurs between vehicles of other directions, and leads to the vicious circle of accumulative congestion.

The 3-way intersections of hexa-city not only eliminate all the hazardous elements of tetra-city, but also enhance the traffic efficiency by reducing the length of a signal-cycle approximately to 1 minute from 3 minutes of conventional crossroads. Drivers can choose lanes single-mindedly and, with broader fields of view while crossing intersections, make smoother traces of about 60 degree turning angle, which provides almost constant running speed without slowdown cornering. On the other hand, pedestrians can cross the roads safely during a sufficient time longer than a half of the signal-cycle without vehicular hindrance.

Symmetrically arranged six-side, six-bent inter-block roads induce vehicles to scatter spontaneously, and congestions can be absorbed within each block by assigning the most crowded facilities of public use to the central area. As vehicles have to stop and park somewhere on the inner-block roads, the disruptions between vehicles are remarkably decreased. Two remote spots on a hexagonal roadway network can be interconnected at the least distance of geometrical equality when compared with any other roadway networks, and vehicles on the roadway can pass the consecutive intersections without meeting any stop signals through the traffic control system of signal synchronization.
Therefore, hexa-cities eliminate the need of circumventing freeways which cause a new traffic problem of frequent jams around their interchanges or junctions.

As two different lines of underground railways installed along the orthogonal roads can come parallel on a floor of a station, passengers can transfer at the same platform.

The fluent curvatures of roadways and railways reduce frictional losses and consuming energies due to the de/acceleration of vehicles. The reduction of travel time and stopping frequency of vehicles enhance the efficiency of traffic, and proportionally, the life span of vehicles and roadways can also be prolonged, and urban pollution can be reduced enormously in result.

All the hexagonal blocks of hexa-cities have six penetrating orthogonal roads allowing better atmospheric circulation. The hexagonal blocks and roads can easily adapt to the non-rectangular, curved boundary of a city, hence make them ideal for development in environment-friendly way by significantly reducing the amount of construction work of straight roads.

The hexa-city innovates the conventional urban planning of vain attempt to solve the traffic congestions with raising the road ratio through widening roads. The hexacity significantly reduces the Earthly resources wasted on the ineffective times and spaces of tetra-cities. Most of all, the present invention will convert human activities for personal exchanges from wide-road oriented outward-dispersion to central-plaza oriented inward-concentration, and thus the modern civilization of mankind will continue into the era of culture.

FIG. 1 shows the basic concept of the present invention. It shows each hexagonal block divided and surrounded by inter-block roads, orthogonal roads drawn as solid lines and subways drawn as (shaded) double lines. Circular roads and arrangements of buildings are omitted for simplicity. The orthogonal roads do not intersect at the center of each block actually, but they are drawn so to help understand the concept.

FIG. 2 shows a constitution of an example city in accordance with an embodiment of the present invention. It illustrates that the widths of roads and the sizes of blocks can be enlarged, reduced, or modified if required.

FIG. 3 and FIG. 4 show that each side of a polygonal block is expanded uniformly as much outer area as the portion of the block’s road ratio.

FIG. 5 shows a 3-way intersection of the inter-block roads and the order of left-turn between the three traffic-lanes (denoted with numbers 1, 2, and 3, respectively).

FIG. 6 shows the turning positions on the roadways occupied fixedly, exclusively by the three pairs of traffic-lanes before passing each intersection.

FIG. 7 shows the status of roadways just when ⅓ of one signal-unit elapsed after the left-turn of the traffic-line number 1 proceeds. Each triangle represents a 3-way intersection, and a small circle represents the crosswalk with the go-signal turned on.

The legends of the figures are as follows.

102: inter-block road
104: orthogonal road
106: unit-block
108: underground railway
500: intersection

BEST MODE FOR CARRYING OUT THE INVENTION

The average size of blocks of a hexa-city can be determined in accordance with the scale of urban areas and the degree of congestions of the city. Assuming each section of the length of 450 meters and the vehicular speed of 50–70 kilometers per hour on the inter-block roads, it takes about 60 seconds to cover two sections of 900 meters. Therefore, the signal-unit is 60 divided by three, namely 20 seconds.

As a group of vehicles, passing a 3-way intersection during one signal-unit at the average speed of 60 kilometers per hour without meeting stop-signals, makes up the extent of near 300 meters, the traffic volume per intersection of the hexa-city can be estimated. On the other hand, as the vehicles of the two traffic-lines competing lanes of a roadway are always apart more than ½ signal-unit, the vehicles of a traffic-line can occupy all of the lanes for an interval before and after passing the intersection. The traffic control system of the hexa-city should be established on the basis of those inferences (Refer to FIG. 7).

During the left-turn of each traffic-line of a roadway, the go-signals of the two adjacent crosswalks of the other side of the roadway are turned on and pedestrians can cross the road half by half through the mid-safety island for a sufficient time of 2 continuous signal-units in a signal-cycle. The pedestrians’ waiting time at the mid-safety island is 0 or 0.5 signal-unit depending on the direction of crossing. Vehicles waiting for U-turning or coming out of the block can proceed their ways during near 1.5 signal-units.

The location and scale of the u-turn zone can be specified according to the fact that vehicles running on the inter-block road gradually disappear from the center to either end of both sides of a section during one signal-cycle.

Meanwhile, vehicles on the orthogonal road, waiting to cross the inter-block road, proceed their ways as well as the pedestrians can cross the road to move to the opposite block during 1.5 signal-units.

MODE FOR THE INVENTION

The description so far is just an exemplified explanation for the technological principles of the present invention, and various modifications are possible within the substantial properties of the present invention. Consequently, the examples deployed by the present invention are for the explanation of the technological principles, not for confining. The protection boundary of the present invention should be interpreted according to the following claims, and the present invention should be interpreted as to include all the equivalent technical concepts.

INDUSTRIAL APPLICABILITY

Enhancing the efficiency of the use of lands, the hexa-city can obtain about 30% of saved land area in comparison to the tetra-city of the identical effective area. The hexacity can be realized in newly constructed cities as well as in existing tetra-cities through long-term, divisional redevelopment or partial restructuring of existing roadway networks. Just like a tetra-city, the hexa-city also contains straight roads such as the orthogonal roads intersecting inter-block roads.
and interconnecting the central parts of the adjacent blocks (Refer to FIG. 1). Projecting to search for areas convertible into 3-way intersections on the city map through overlapping the parallel roads of the tetra-city and the corresponding orthogonal roads of a direction, the plan to convert into hexa-city with minimum construction overheads could be established.

[0109] Through such conversion, the following innovations on the urban planning and development can be expected.

[0110] First: Rezoning to convert the existing broad roads into newly developed series of urban areas in accordance with the urban planning is possible.

[0111] Second: Upward equalization on the urban development is possible on account of rising of the under-developed backside areas to the central places of 3-way intersections.

[0112] Third: Converting the extra areas created by the reduction of ineffective areas into the environmental, economical value is possible.

1-8. (canceled)

9. The hexagonal roadway system of the urban areas of a city comprising:
   a plurality of intersections each being connected normally with three adjacent intersections of an identical kind in different directions through the respective sections of the inter-block roads dividing every unit-block and being overground, single-leveled and double-sided;
   a plurality of orthogonal roads being formed by connecting the respective central parts of adjacent unit-blocks one another and intersecting the corresponding said inter-block roads;

   a plurality of circular roads being arranged in appropriate mutual intervals and intersecting every said orthogonal road inside each said unit-block; and

   a traffic control system capable of centralized control over said inter-block roads.

10. The hexagonal roadway system of claim 9 including:
   underground railways being installed under said orthogonal roads and being paralleled between a plurality of different lines on the identical level of a platform of a station.

11. The traffic control system of claim 9 including:
   the signal-cycle being defined to be the approximate value of double the required time for a vehicle to run one said section at a specific speed and being applied identically at every said intersection;
   a signal-unit being defined to be a segment of one third of one said signal-cycle; and

12. The traffic control system of claim 9 including:
   a left-turn signal for a pair of said traffic-lines being generated simultaneously at each said intersection during a said signal-unit.

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