

THE ROLE OF INNOVATIVE TECHNOLOGIES AND ISSUES RELATED TO THE EFFICIENCY OF 3D PEDESTRIAN STREET CROSSING

Irina BAGHDASARYAN

Ph.D., Associate Professor, Department of AUPEWR,
Shusha Technological University, Artsakh, Stepanakert

Anzhela BARSEGHYAN

Ph.D., Associate Professor, Department of AUPEWR,
Shusha Technological University, Artsakh, Stepanakert

Key words: innovative technologies, pedestrian crossing, paintwork material, road marking, durability, layer stability, crack resistance, bending strength, road surface, slow-burning material

Introduction. Innovation technologies play an increasing and significant role in all areas of economy and human life. Increasing the efficiency of the functioning of vehicles on Artsakh roads, the level of high accident rate, namely collisions with pedestrians, create serious unrest. Therefore, unusual zebra crossings are created and applied to the asphalt surface using 3D technology that turns ordinary urban details into art objects and looks like concrete blocks hanging over the road and casting a shadow on it, they are also very visible from afar. It is this factor that will force vehicle drivers to slow down in advance in order to let pedestrians through.

Methodology. We have used empirical method to examine the state of efficiency in the streets of Artsakh, particularly, the efficiency of pedestrian crossing. In addition, we have analyzed the experience of different countries related to the utilization of innovative technologies for making safe and comfortable pedestrians movement across the street, therefore the method of comparative analysis is also used in our study. In addition, we have used visual methods such as pictures and graphs, as well as designed tables based on economic and technical information available for the mentioned topics. Finally, we have used the method of gathering, evaluating and analyzing statistic data and statistic lines.

Literature review. While examining the state of efficiency related to pedestrian crossing and the use of 3D technology, we have paid attention to various scholarly articles. In particular, some experts have examined the walking accessibility to neighborhood open space in a multi-level urban environment. In Hong Kong, for example, [Tang, Wong, Tang, 2021, 34] a 3D pedestrian network of the whole was developed and experts studied the peculiarities of formal pedestrian crossing. Following Oh and Jeong have paid keen attention to the socio-economic characteristics of the residents in this area. Others have analyzed pedestrian crossing action prediction using transformer [Lorenzo, Alonso, Izquierdo, Ballardini, 2021, 12] and the considerable impact on the economy. They have witnessed less part of pedestrians standing on curbsides Effectiveness of augmented reality warnings on driving behavior is evaluated whilst approaching pedestrian

crossings. In addition, target pedestrian crossing intention is inferred using a 3D innovative technology. Other works are related to the red arrow that was created in the modeling software 3D. In this way, although the participants could not be economically reactive, shows a statistically significant main effect of AR warnings. While some authors concentrate on pedestrian crossing design and analysis for symmetric intersections (efficiency and safety) [Calvi, D'Amico, Ferrante, Ciampoli, 2020, 76], others believe that the symmetric intersection (SI) can increase the capacity of intersections and is economical [Tang, Liu, Li, Qi, Zheng, Chen, 2020, 119]. Deeper analysis was conducted by a group of experts [Karaaslan, Noori, Lee, Wang, Tatari, 2018] focusing on a real intersection is simulated in 3D using AnyLogic software for a vehicle pedestrian interaction in pedestrian crossings and other, in terms of economic status, etc.

Scientific novelty. The primary goal of our analysis is to justify the need to develop better pedestrian crossing in Artsakh, as well as improving the innovative technologies that might have beneficial economic consequences and indeed improve public awareness on safety on roads. We also pay attention to zebra crossings at T-intersections to reduce the likelihood of unintended negative consequences for safety and walkability. Furthermore, we intend to continue our study to gain automatic pedestrian crossing detection and utilize mobile mapping system.

Analysis. The world of people's illusions is multifaceted, and, namely, drawings on asphalt using 3D technology, drawn, proves how talented artists create irresistible masterpieces, expand ideas about unusual phenomena. (Fig.1.). The creation of such an unusual masterpiece, and this type of art itself, is extremely difficult, since the artist needs to constantly monitor the perspective, and one wrong movement is enough - the whole illusion crumbles [Dictionary, 2022, 10].



Figure 1. 3D drawings on asphalt.

In conditions of intensive and uninterrupted movement of vehicles in Artsakh (Nagorno-Karabakh), the increase in the efficiency of the operation of road transport and their harmonious development are inextricably linked with an increase in the capacity of the road network, as well as the level of high accident rate, in particular collisions with

pedestrians, creates serious social unrest. Therefore, it is necessary to develop and implement effective measures to prevent road accidents (RTA), reduce the number of dead and injured in them, for example, one of the ways to solve such problems is the creation of modern 3D pedestrian "zebra" technology. In the modern world, unusual pedestrian crossings are being created, which are traditional rows of white stripes - this is the "zebra" due to the similarity with the black and white stripe on asphalt [13], and they are applied using 3D technology, which creates an optical volume illusion. A strong visual warning - as if a zebra is rising above the asphalt, and pedestrians' legs are moving through the air (Fig. 2) - will force drivers to significantly slow down before a pedestrian crossing, consequently, and will increase the level of safety on the roads.

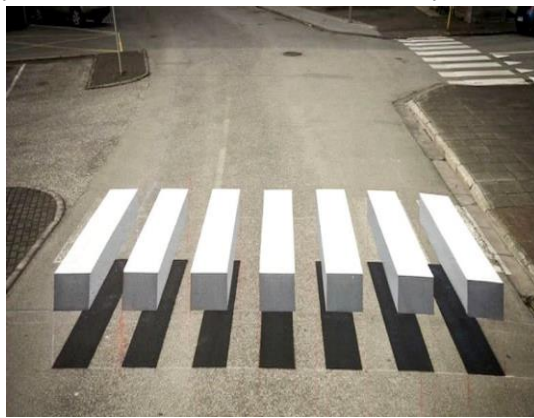


Figure 2. Walking zebras in 3D.

The popular 3D technology is based on the principles of human vision, because all objects that surround people in the real world have three dimensions - the height, length and width of the object, but even "by eye", it is possible to determine the distance to the object and its approximate volume, however, the depth of space, which is between a person and an object, is also perceived here. Considering the above mentioned facts, all objects have a three-dimensional image and depth too.

Throughout Artsakh, on especially dangerous sections of roads, there are "lying policemen", i.e. artificial elevations on the roads to control the speed of transport in especially accelerating sections [Krovlja, 2022, 5]. There are several types of such artificial elevations on the roads:

- Plain asphalt (this is an old version, it can be found in small towns and villages). They are inconvenient, difficult to repair and install.
- Rubber (common option). Rubber "speed bumps" cope well with loads, have a small shock-absorbing property and save the car's suspension.
- Metal (composite). Such "speed bumps" are strong, reliable, durable option, and the cost is more expensive compared to the previous two options [Lezhachij, 2022, 7].

All 3 types of "speed bumps", regardless of the material produced, disrupt the continuity of traffic, driving over such artificial bumps (over "speed bumps"), cars radically change their technical characteristics [Strojpolimer, 2023, 11]:

1. as a result of braking, jumping over bumps, and especially subsequent acceleration, fuel consumption increases when driving through these sections;
2. the level of emissions of harmful substances increases and the air is polluted with the release of carbon monoxide and nitrogen oxides;
3. increases the risk of cancer, respiratory and cardiovascular diseases for residents of nearby homes;
4. during the day, drivers, repeatedly driving over artificial uneven obstacles, repeatedly reduce speed and back, unnecessary additional stresses of drivers appear (reflectors become dull, they get tired ahead of time), all this cannot but affect traffic safety;
5. an inconvenience for passengers, especially in public transport and each "jump" over a "speed bump" strikes at the spine of any passenger inside the bus.

New technologies for the production of paints and varnishes allow you to create high quality paint. Such paints must be resistant to the difficult weather conditions of the Artsakh climate. The paint can be applied to the asphalt pavement either cold (paints and plastics) or hot (better marking with thermal materials is obtained) - plastic heated to certain temperatures before application provides much better required properties such as durability, durability, resistance to temperature extremes, good visibility under various conditions. In the case of applying a zebra with paint, special additives that reflect light well can be added to its composition. For painting on asphalt (or the surface of a concrete screed as a road surface), special types of paint have been developed. They are distinguished by good adhesion (the ability of a paint coating to adhere or strong adhesion to the painted surface) and high abrasion resistance [Nacievskij, Homenko, 1980, 264]. Taking into account the property of durability of paints and varnishes, materials of 5 classes are used for marking.

Table 1. Marking material classes

Material class	Material
1	1st class paint
2	Paint class 2 (wear-resistant)
3	Spray plastic (layer thickness up to 1.2 mm)
4	Thermoplastic, marking tapes (layer thickness 2-4 mm)
5	Cold plastic (layer thickness 2-3 mm)

For roads with different traffic intensity, the approximate consumption of paintwork material can be taken in accordance with Table. 2. [3, 4, 6].

Approximate consumption of paint for roads with different traffic intensity

Table 2. Consumption of paintwork material

traffic intensity, avt/day	Paint consumption, g/m ²
1000-3000	350-400
3000-7000	400-500
Более 7000	500-600

The advantages of paints and varnishes for pedestrian markings are as follows:

1. Protection. The coating improves the impact, abrasion and chemical resistance of asphalt (or concrete).
2. Appearance. With the help of paint, it is possible to create attractive color solutions for distances and apply markings.
3. Paints increase chemical resistance, improve friction, prevent the accumulation of static electricity.

The paint and varnish material applied to the surface of the asphalt pavement (or concrete) avoids increased dust formation. When the thinnest dust film forms on the surface to be painted, the markings dry out. If the film loses tack to the touch and the painted surface to be painted can undergo further drying operations, then touch dry (this is practical).

The main properties for road markings are as follows:

- a) Good visibility of the markings in any weather or time of day. The safety of road use depends on this;
- b) wear resistance. The coating must resist mechanical abrasion under the influence of car tires well;
- c) Weather resistance. Ultraviolet radiation, rain, snow, temperature changes - all these are destructive factors for marking, which it must successfully resist.
- d) Road markings should not impair the grip of car tires with the road surface. [3, 4, 10, 11]. Road markings on the asphalt should not be washed off after the first rain and go along with the snow (Fig. 3).

Asphalt - from ancient Greek means "mountain resin" - mineral resin (the historical name is "Jewish resin"), is a black or black-brown, highly shiny substance (bitumen

mixed with fine mineral aggregate and sand). The resin melts at 100 °C, dissolves in turpentine oil, oil and gasoline, and is a kind of natural bitumen [Prohorov, 1989, 632].

The asphalt mortar after hardening, which occurs due to the hardening of bitumen, has sufficient density, water resistance, strength and heat resistance. If bitumen is used in excessive quantities, as well as with a low softening temperature, the heat resistance of asphalt decreases. On average, the bitumen content in the solution is in the range of 9-11%. [Belov, 2006, 16]. Asphalt pavement is smoother and therefore less noisy than cobblestones and paving stones (roads in ancient times).

The asphalt concrete pavement is easily repaired, washed and removed, it has the necessary roughness and any road markings adhere well to it.



Figure 3. Road markings on the asphalt are washed off.

On the laid asphalt concrete, traffic can be immediately opened, unlike cement concrete, because cement concrete gains its required strength only on the 28th day. Therefore, asphalt is the most suitable paving material.

The strength of asphalt depends on several quantities:

- Stability of the layer under the action of vertical and horizontal loads.

Vertical load is the wheels of cars, horizontal load is the braking force.

- Fracture resistance - is determined in autumn - winter period, when the coating settlement increases.

- Flexural strength is taken into account in the spring, when the underlying layers absorb water to a small extent and create a risk of micro-failure accumulation (fatigue failure). Such fractures appear under the action of repeated non-rhythmic impact, they turn into cracks due to insufficient bending strength.

Currently, 3D pedestrian crossings are available in many countries: in the USA, France, Great Britain and Iceland. Experiments are underway in London. During the

year, due to the presence of an unusual zebra, the average speeds in these countries decreased by almost 40%¹. 3D markings are much cheaper and more profitable compared to some types of speed bumps. Comparative characteristics are given based on a road width of 8 meters (table 3).

Table 3. Comparison of 3D markings and speed bumps

Types of device	Recumbent policeman made of composite	Rubber recumbent policeman	3D marking
Required number of sections	16 pieces	16 pieces	5 lines
Life time	5 years	5 years	1 year
Price	736 AMD	31,6 AMD	48 AMD

We may conclude based on the above data that the marking is cheaper and more cost-effective than a rubber speed bump, but its service life is only 1 year, which is much less than the service life of the composite material, and when using 3 markings within 5 years, the cost of its maintenance will be 240 AMD, while its cost benefit will be observed during 15 years of use.

Conclusions. Thus, in 3D format - "zebra" is designed to attract the attention of drivers of vehicles, not to distract their eyes from the traffic situation;

1. 3D pedestrian crossing is an effective, original and inexpensive solution. Bright markings attract additional attention of drivers when approaching a pedestrian crossing;
2. Studies and tests show that such an unusual road marking solution has a positive effect on the overall safety of roads due to a decrease in the speed of drivers;
3. Paint and varnish material for marking on asphalt (or concrete) does not eliminate surface defects, therefore, before applying it, it is necessary to putty chips and cracks with a special putty;
4. When choosing a paint, three parameters must be taken into account: the climatic features of the region, traffic intensity, types and characteristics of the road surface or road equipment elements;
5. Pedestrian "zebras" with a three-dimensional effect can replace speed bumps;
6. The image of an artificial roughness ("lying policeman") in 3D format, forces drivers to slow down on the road and does not contradict the law;
7. For the road surface, not only the value of the load is important, but also its duration. However, it is not possible to evaluate this factor; therefore, the ultimate strength value is used for the characteristic, i.e. the stress at which asphalt concrete is destroyed;

¹ <https://lifeglobe.net/entry/1395>

8. Asphalt concrete is a slow-burning material, i.e. under the influence of high temperatures or open fire, the material smolders, chars or ignites, and when the fire is removed, the smoldering or combustion itself stops;

9. Asphalt pavement is harmless, because the mineral, organic constituent materials do not emit any fumes, so the environment is not poisoned, therefore, asphalt is considered environmentally friendly.

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